MANUAL ON DATA COLLECTION, PROCESSING AND PRESENTATION

SHORT TERM ROUTINE MEASUREMENT PROGRAMME

The 'Reuse of Drainage Water Project' is a joint activity of the technical agencies:

Drainage Research Institute (DRI), Giza/Cairo- Egypt
and
Institute for Land and Water Management Research (ICW), Wageningen, The Netherlands

The Project is funded by the Ministry of Irrigation of Egypt and by the Ministry of Foreign Affairs of the Netherlands in the framework of the joint programme of Technical Cooperation between Egypt and the Netherlands.

The Advisory Panel for Land Drainage in Egypt acts as steering committee.

The results of studies, carried out in the 'Reuse of Drainage Water Project', will be presented in preliminary reports and in a final report. As such the contents of preliminary reports can vary strongly, from a simple presentation of data to a discussion of research results with tentative conclusions.

All opinions, conclusions and recommendations in these reports are those of the authors and neither those of the cooperating Institutes, nor of the Ministry of Irrigation of Egypt or the Ministry of Foreign Affairs of the Netherlands.

REUSE OF DRAINAGE WATER PROJECT

REPORT 1

MANUAL ON DATA COLLECTION, PROCESSING AND PRESENTATION

SHORT TERM ROUTINE MEASUREMENT PROGRAMME

C.W.J. Roest

1983

INSTITUTE FOR LAND AND WATER MANAGEMENT RESEARCH

PO BOX 35, 6700 AA WAGENINGEN, THE NETHERLANDS

ACKNOWLEDGEMENT

This report is the result of the author's presence in Egypt from 1977 till 1982 and two consultant missions during 1982 in February/March and in April/May. By the end of 1981 the request was made to prepare a manual on the routine measurement programme on reuse of drainage water, a programme that has been initiated by the Drainage Research Institute under the auspices of the Advisory Panel on Land Drainage in Egypt.

The author whishes to express his graditude to Dr. Mohammed Hassan Amer, the director of the Drainage Research Institute, under whose guidance the reuse of drainage water study has grown till its present strength. Acknowledgements are due to Dr. Samia El Guindy, who, besides her work as head of the Laboratory Division and head of the Economic Evaluation Division of DRI always was prepared to coordinate the work of the Reuse Division, and took part in many activities. She made a great contribution to the achievements of the reuse of drainage water study. The author whishes to thank dr. Dia El Din El Quesi, who, after joining the Drainage Research Institute in the course of 1980, very quickly became acquainted with the reuse of drainage water study and gradually took over part of the duties of dr. Samia El Guindy as head of the Reuse Division. At present dr. Samia El Guindy and dr. Dia El Din El Quesi jointly guide the activities of the junior engineers of the Reuse Division.

The least agreeable part of the work for the routine measurement programme has been done by the junior engineers of the Reuse Division for which they are commended. Without pretending to present an exhaustive list of the engineers who work or have been working in the Reuse Division some will be mentioned here: Engs Mohamed Saad Abbas; Samir Abdel Hamid; Mohamed Abdel Khalik; Gamal Abdel Nasser; Adel Abdel Rashid; Mohamed Eissa; Mohamed Ezzet; Sami Farghaly; Mohamed Naguib Hafez; Oweis Hamid; Abdel Moneim Matbuly; Ahmed Morsi.
Without their continuous efforts under - often - difficult circumstances the field data collection would be at a much lower level of implementation. The author whishes to express his satisfaction for having been able to work with them.
The support of the teamleaders of the Drainage Panel Project, ir. I.A. Risseeuw (until January 1980), ir. J.A. van 't Leven (until April 1980) and ir. H.J. van der Zel (since May 1980) has been of great help.

The work for this manual that has been initiated as one of the Drainage Panel Project activities has been terminated with assistance of the Institute for Land and Water Management Research (ICW) in Wageningen within the context of the 'Reuse of drainage water project' that recently (1983) became operational.

TABLE OF CONTENTS

1. INTRODUCTION

Reuse of drainage water for irrigation purposes, not a new concept in Egyptian agriculture, has become an official strategy of the Ministry of Irrigation, in order to supply part of the envisaged extension of the agricultural acreage in the future with water.

In order to — successfully — reuse drainage water for irrigation purposes the effects of the salts present in the drainage water on soils and crops should be evaluated. For the planning of the implementation of reuse of drainage water projects it is of prime importance to the Ministry of Irrigation to acquire knowledge about quantity, quality and location of the available drainage water resources. Already since 1954 the Soil and Water Research Institute (Ministry of Agriculture) has been involved in studies concerning quantity and quality of drainage water in Egypt. Also the effect of salinity on soils and crops has received attention by this institute by means of laboratory experiments.

Since 1976 the reuse of drainage water as a subject of study came to the attention of the 'Advisory Panel for Land Drainage in Egypt'. Since 1977 the Drainage Research Institute (DRI) started to collect watersamples from about 47 drains and drainage pump stations spread over the Nile Delta on a monthly basis. This water sampling programme is still in existence.

The measurement programme of DRI received new impetus since 1979. Upon instigation of VOLKER (1979a, 1979b, 1980) the open drainage system in the Nile Delta and Fayum Depression has been surveyed by field inspection and a systematic network of measurement points (app. 90) has been indentified (fig. 1-1). Since 1980 data on discharge and water quality have been collected on a fortnightly basis, using very simple measuring methods. This measurement programme is still in existence.

Complementary to this data collection programme, DRI started during 1981 with a calibration programme, through the involvement of the Delft Hydraulics Laboratory (SCHOONMAN: 1981a, 1981b, 1982). This programme has been initiated in order to establish the discharge rating curve's of the measurement network identified. The programme is still under execution.

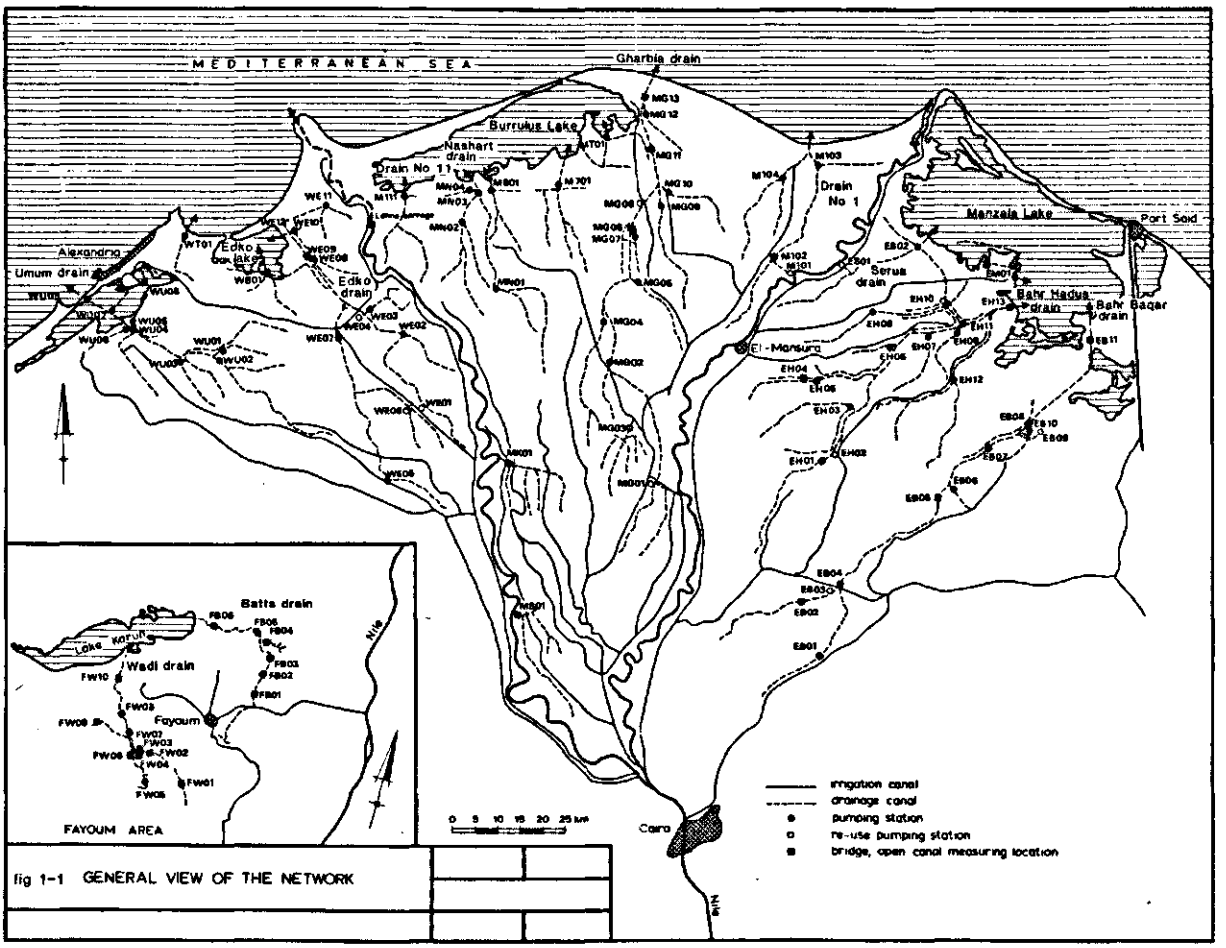


fig 1-1 GENERAL VIEW OF THE NETWORK

Since 1981 DRI initiated actions to develop a mathematical model describing the relations between irrigation, drainage and crop production for the Nile Delta through the involvement of the Institute for Land and Water Management Research, Wageningen (RIJTEMA:1981, 1982; RIJTEMA AND ROEST, 1982). The development of a mathematical model implies that the measurement programme under execution at present has to be refined with respect to network density, measurement frequency and accuracy.

The subjects treated in this report will be confined to the fortnightly measurement programme, effective since 1980, and the calibration programme, effective since 1981. On a modest scale DRI has already started with the installation of field equipment for daily observation. Some of the procedures given in this report may be used for these observations as well; others may serve as a basis for developing new, adapted, procedures.

The objective of this report is to present a self explanatory manual for the field observations, data elaboration and presentation procedures for the junior staff working in the Reuse Division of DRI including background information and practical examples. The manual may be used as a reference guide for the junior engineers, but may also be useful as an introduction for new staff joining the Reuse Division.

In chapter 2 of this report the field data collection procedures,common in the DRI measurement programme, are described in detail. In chapter 3 the laboratory analyses of the watersamples collected is treated. In chapter 4 the data elaboration, in chapter 5 the data checking and in chapter 6 the data presentation procedures are given. The raw field data used for illustration throughout this report are presented in annex 1; the elaborated, corrected and data formatted for presentation are given in subsequent annexes. The user of this manual can apply the procedures given in the text to the data in annex 1 and follow these data through the annexes 2, 3, 5, 6 and 7. Detailed examples of calculations have been provided in the text.

2. FIELD DATA COLLECTION

The measuring methods, adopted in the short term programme, are, with exception of the calibration measurements, very simple. However, simple the method it is very important that the measurements are performed with the required care and that the equipment used is properly cleaned and maintained. It is equally important that the results are noted on the proper measurement forms (see annex 1) to avoid confusion in the interpretation of these results at a later stage, in the data processing.

2.1. DISCHARGE MEASUREMENTS AT PUMP STATION

At pump stations the discharge measurements are the responsability of the pump station engineer and the pump operator (Ministry of Irrigation). They fill in special forms for the operation hours of the pump units and the water levels of the drain at suction and delivery side of the drain.

In the future these measurements will be facilitated and the accurary improved, by installation of time counters on the pump units and water level indicators on both the suction and delivery side of the pump station. These water level indicators consist of a clockwork that is moved by a float, mounted in a pipe that can easily be attached to the side walls of the approach and delivery channels of the pump station.

2.2. DISCHARGE MEASUREMENTS AT OPEN DRAINS

The basic discharge measurement methodology is to measure both the wetted cross section and the flow velocity. The wetted cross section is measured by measuring the waterdepth at a reference point in the cross-section and the velocity is estimated with float measurements. Complementary to the float measurements the vertical flow velocity distribution is determined with the hand pendulum meter at the reference point.

Not at all measurement locations the pendulum measurements are performed: at some locations the waterdepth is too shallow for measuring according to this method (see p.e. annex 1.2); at other locations obstructions besides the bridges prevent its application. On some locations the float measurements are not performed due to absence of access to the drain by means of a bridge (see p.e. annex 1.8).

The following equipment is available for these measurements:

+ for measurement of the cross section:
  - measurement tape;
  - sounding rod;
  - levelling instrument and staff.
+ for measurement of the waterdepth:
  - measurement tape with suspended weight.
+ for measurement of flow velocities:
  - stopwatch.
+ for measurement of the vertical velocity distribution:
  - hand pendulum meter with resistance bodies.

First the measurement of cross sections will be treated.

The measurement tape is used to measure the width of the bridge (traveling distance of the floats) and to measure the distance between the points where the distance between bridge surface and drain bottom are measured. The measurement tape should not be allowed to lie loosely on the bridge surface, but should be stretched slightly during measurement. After measuring, dirt and water should be removed from the tape and regularly a steel tape should be greased to prevent rust.

The sounding rod (fig. 2-1) is used to measure the the distance between the bridge surface and drain bottom.
The rod is made of 0.5 inch diameter tubes of exactly 1 m long. The bottom element is welded to an iron plate Ø 10 cm, to prevent subsidence of the rod in the soft drain bottom material. The pieces of 1 m can be screwed together to any desired length.

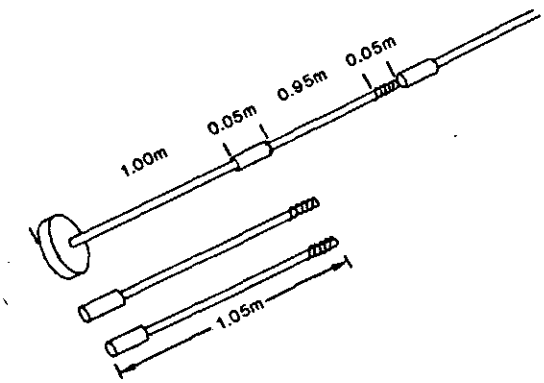


Fig. 2-1. Sounding rod

Measurements are performed as follows:

- place the rod along the bridge at the required place;
- let the rod rest on the drain bottom without pushing it down. If the rod tends to subside slowly, lift the rod slightly to prevent subsidence;
- count the number of elements (pieces) below the bridge surface;
- measure the distance between the top of this last piece and the bridge surface (excess) and write down the results (no of pieces and excess in cm) on the measurement form (see annex 1).

No special maintenance is needed.

The levelling instrument and staff (fig. 2-2) are used to correct the distances measured with the sounding rod for differences in elevation of the bridge surface. If the bridge surface is smooth and straight 3 observations in the centre and on both ends of the drain on both the upstreams and downstreams side of the bridge are sufficient (annex 1.3).

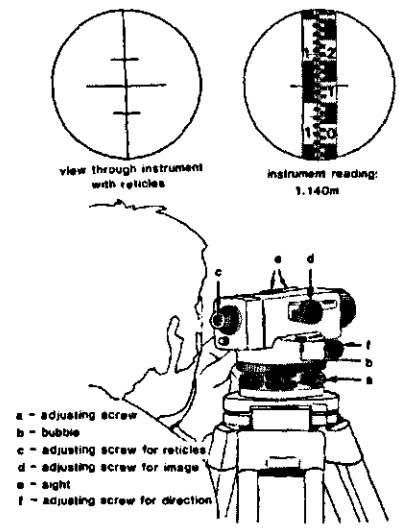


Fig. 2-2. Levelling instrument and staff

If the bridge surface is irregular, all observation points should be measured (annex 1.4).
Measurements are performed as follows:

- select a location from where all observation points can be viewed and place the tripoïd;
- fix the instrument on the tripoïd and adjust the bubble, b, (fig. 2-2) in the centre of the window using the adjusting screw's, a, (3 screws);
- move the adjusting screw, c, in order to obtain a clear view of the reticles;
- place the staff properly vertical on the observation point;

- direct the instrument roughly in the direction of the staff by hand using the sight, e,
- adjust the image of the staff with the adjusting screw, d;
- adjust the direction of the instrument with the adjusting screw, f;
- read the middle reticle (fig. 2-2): the number of decimeters is written on the staff; the number of cm can be counted (each block is 1 cm); the number of mm have to be estimated. Record the results on the measurement form (annex 1).

The levelling instrument should be kept free of dust and moisture. Especially rainfall may be harmfull to the instrument. Whenever the instrument has been accidentally wetted, it has to be returned to the dealer's workshop for cleaning and checking. The staff should be kept clean to avoid mis-readings and should regularly be examined on possible damages (for example et the hinges'location, if the staff can be folded).

The complete procedure for a cross-section measurement is as follows:

1. Determine the zero-point and the end-point of the bridge (fig. 2-3), on the upstreams side. Mark these points on the bridge surface with paint. Make a situation sketch of the measurement point and indicate the zero-point (annex 1).
2. Measure the distance between these points with the measurement tape and divide this distance in 5 to 20 sections with width w in such a way that w is 1, 2, or 4 meter. Record the total drainwidth on the situation sketch of the measurement point.
3. Paint on the bridge surface in the middle of each section the distance to the zero point. If w = 1 these distances are 0.5, 1.5, 2.5 etc. If w = 2 these distances are 1, 3, 5 etc. The last section besides the end-point, will have a width smaller than w. If the width of this section is smaller than ½w the last section and the previous last one should be considered together as one section. If the width of the last section is bigger than ½w it should be considered as a seperate section. In both cases the distance to the zero-point should be painted in the middle of the section.
4. Measure the distances to the zero-point and the thickness of the piers below the bridge and record the results on the measurement form (annex 1).
5. Measure the distance between bridge surface and drain bottom, following the instructions given to the sounding rod with intervals of ½w, starting from the identified zero-point and ending with the end-point. Record the results on the measurement form in terms of number of pieces and excess in cm (see annex 1).
6. Determine the zero-point on the downstream side of the bridge.
7. Measure the distance between bridge surface and drain bottom on the downstream side and record the results.
8. Identify a reference point on the downstream side. Select a location where the flow velocity is reasonably high and the flow is un-obstructed (piers!). Mark the reference point with paint.
9. Measure the distance between bridge surface and drain bottom at the reference point and record the results on the measurement form.
10. Measure the width of the bridge and record it on the situation sketch of the measurement point.
11. Measure the relative elevation of the bridge surface following the instructions for the levelling instrument and staff. Measure at intervals of ½w,

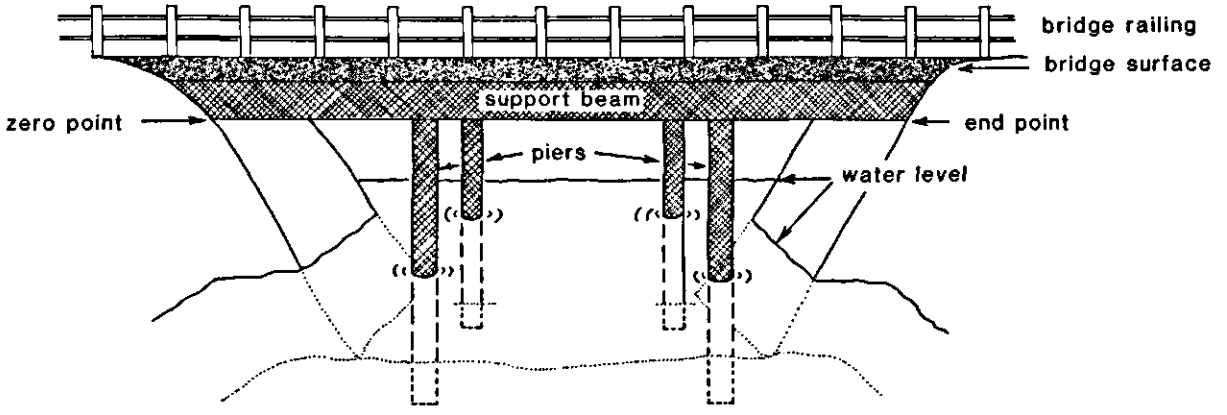


Fig. 2-3. Upstream front view bridge

starting with the zero-point and ending with the end-point on both (upstream and downstream) sides of the bridge, if the bridge surface is irregularly shaped. If the bridge surface is smooth and straight three measurements at the zero-point, end-point and in the centre on both (upstream and downstream) sides of the bridge is sufficient. Include the reference point! Record the results on the measurement form (annex 1).

12. Record the date of measurement on the measurement form.

The measurement of cross sections should be repeated if there are indications that the cross section is changing due to sedimentation or erosion of the drainage channel. When, upon the yearly check of the depth at the reference point, a new measurement of the cross-section is warranted the steps 1, 2, 4, 6, 8 and 10 from the measurement procedure can be omitted.

The fortnightly routine measurements proceed as follows.

The measurement tape with suspended weight (fig. 2-4) is used to measure the distance between the reference point on the bridge surface and the water level. The weight is attached to the tape to prevent the tape to be blown away by the wind. The weight should be lowered gradually while the tape is moving freely from the bridge preventing damage to the tape, untill the weight touches the water. Now the tape is moved towards the bridge with the marked side of the tape facing the observor. The distance, Hm, can be read directly and should be recorded on the measurement form (see annex 1). If the marked side of the tape is not facing the observor, the tape has to be bent on the bridge's edge resulting in possible damage to the tape and in accurate readings.

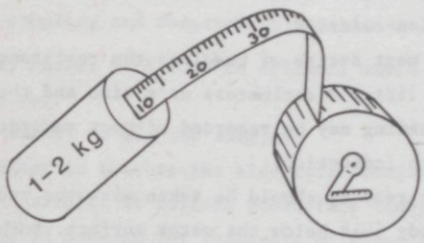


Fig. 2-4. Measurement tape with suspended weight

After use the tape should be cleaned, if necessery, and a steel tape must be regularly greased to prevent rust.

The floats and stopwatch are used to measure the surface water velocities in the middle of the sections with width, w. The distances where the velocities have to be measured are painted on the bridge surface. For the floats any floating material can be used, but the ancient shells (fig. 2-5) that are found in plentiful supplies in the desert area near Maadi have proved to perform best. They suspend for about 2/3 below the water surface and due to their rounded shape disturbing wind influences are minimal. The floats should be thrown into the drain a small distance of 1-2 m upstream to allow adjustment to the flow velocity.

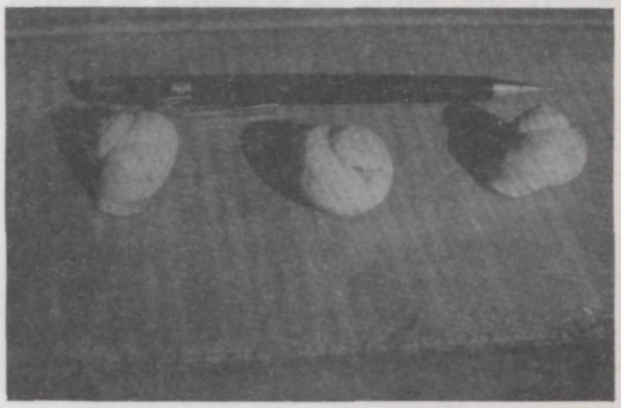


Fig. 2-5. Shells, used as floats for the routine programme

When the float passes the edge of the bridge the stopwatch is pressed. Take care not to press the stopwatch too early (fig. 2-6); the observors' line of sight must be truly vertical. When the float passes the downstream edge of the bridge the stopwatch is pressed again and the travelling time recorded on the measurement form (see annex 1). It is <u>not</u> recommended to work with two observors: one upstream with stopwatch and one downstream signalling the float

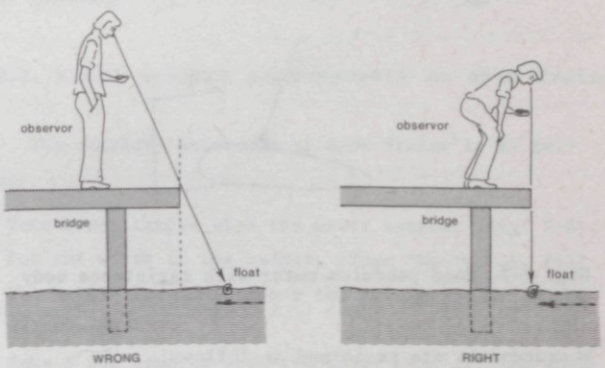


Fig. 2-6. Use of the stopwatch to measure the travelling time of the floats

appearance. Each observor has a certain reaction time and in this case the reaction time of observor 1 (the time between seeing the float and yelling to observor 2) and the reaction time of observor 2 (the time between hearing the yell and pressing the stopwatch) are added and increased inaccuracy results. In order to avoid confusion in the recording of results the measurements are recommended to proceed from the zero-point of the bridge to the end-point.

The stopwatch should be regularly (at least dayly) be rewinded and from time to time its accuracy should be checked against other stopwatches.

The hand pendulum meter with resistance bodies (fig. 2-7) is used to determine the vertical velocity distribution at the reference point. The principle of its operation is that a resistance body is lowered into the flowing water. The deflection of the cable is then a measure for the flow velocity. There are four types of resistance bodies marked K, L, M and N, each one of them gives a specific velocity measurement range. The resistance bodies K and L are produced from a lighter material than M and N, and the bodies K and M have a greater volume and surface than L and N.

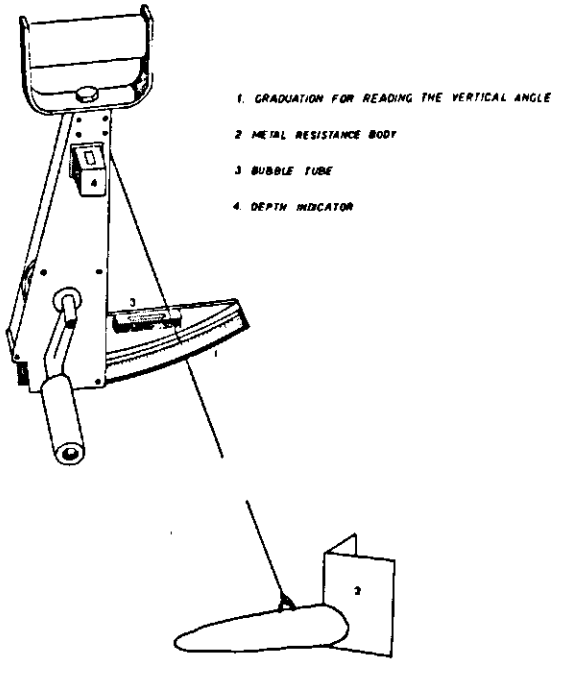


Fig. 2-7. Hand pendulum meter with resistance body

Measurements are performed as follows:

- take the pendulum meter from its case and assemble the meter. Select a resistance body that probably will give scale readings in the range of 10-25° (by experience);
- place the meter on the railing, or on the bridge surface and lower the resistance body to approximately 50 % of the waterdepth. Take a rough reading of the angle to check wether the observations are within the desired measurement range (10-25°). If the reading is above the scale reach (max. 30°) a smaller or heavier body has to be attached. If the reading is below 10° a bigger or lighter body has to be attached;
- after attaching the proper resistance body the code K, L, M or N should be recorded on the measurement form (see annex 1). This is of vital importance for the calculations and should not be forgotten!;
- lower the resistance body until it rests on the drain bottom (the cable will hang loose, or will suddenly be dragged far away with the flowing water). In order to obtain the first reading with the resistance body just freely above the drain bottom the resistance body has to be lifted slightly and slowly and lowered again. After repeating this procedure several times the readings will gradually be lowered (the resistance body will move towards the bridge);
- for the first reading the depth indicator (in decimeters) should be read and recorded on the measurement form. Keep the bubble in the centre of the bubbletube (fig. 2-7) and take the first reading of the angle. Record the results on the measurement form;
- lift the resistance body untill the depth indicater gives an even number of decimeters. Record this depth indication on the measurement form. Wait a few seconds untill the angle reading becomes constant while keeping the bubble in the centre of the bubble tube and record the result. Sometimes the cable keeps swaying due to turbulences in the water. In this case the reading has to be taken as the average between the maximum and the minimum deflection observed;
- for the next series of readings the resistance body is lifted 2 decimeters at a time and the angle reading may be recorded without recording the depth indication;
- the last reading should be taken with the resistance body just below the water surface. Both the depth indication and angle have to be recorded.

It must be prevented that the cable is moving along the bridge edges while lowering or raising the resistance body, especially when the body is still in the air, because this will cause damage to the were and may result in excessive loss of resistance bodies. This can be prevented by the observor by

keeping his foot in between the cable and the bridge edge. Daily, but at least before each field trip, the first few meters of cable that may have been subjected to this kind of damage should be checked on abrasion and wear. If this is the case these few meters should be removed. It is much easier and cheaper to obtain a few coils of the — light weight — wire than to purchase new resistance bodies. The moving parts of the hand pendulum meter have to be oiled regularly.

The complete procedure for the routine discharge measurement is as follows:

1. Measure the reference depth, Hm, at the reference point with the measurement tape and suspended weight. Record the result.
2. Measure the travelling time of the floats in the sections painted on the bridge surface. Start with the first section besides the zero-point and proceed to the end-point. Record the result.
3. Measure the vertical velocity distribution at the reference point following the instructions for the hand pendulum meter. Record the resistance body type. Keep the bubble in the centre of the bubble tube during measurements. Record the results on the measurement forms (annex 1).
4. Record the date on the measurement form!

2.3. WATER QUALITY MEASUREMENTS

Water quality measurements are generally done by sampling and laboratory analysis. The electrical conductivity is measured in the field mainly as an check on the exchange of water bottles during handling and transport from the field to the laboratory and in the laboratory.

The following equipment is available for the field sampling and observation activities:

- small bucket with rope to collect, surface (sub) samples;
- big bucket to mix sub samples;
- EC meter to measure the electrical conductivity;
- water sampler to collect subsurface (sub) samples;
- numbered bottles for transport of water samples to the laboratory.

Always the first (sub) sample taken at a location has to be used to rinse the equipment to be used, including the water sample bottle. The operation of the EC meter has to be checked regularly in the laboratory. Before each field trip the batteries should be charged for a few hours and the maximum scale reach adjusted. The liquid display of the EC meter is liable to damage due to shocks and vibrations. Therefore the meter should be transported with care (not in the car's luggage compartment).

2.3.1. Water quality measurements at pump stations

The complete procedure at pump stations is as follows:

1. Take a sub sample from the delivery side of a pump unit that is in operation using the small bucket. Rinse the bucket and put the water in the big bucket. Fill the water bottle for 50 %, rinse, and throw the water away. Rinse the big bucket and throw the water away.
2. Take sub samples from the delivery side of each pump unit that is in operation and make a composite sample in the big bucket.
3. Take the EC meter, switch it on, and stirr the probe a few times through the water in the big bucket. Keep the probe motionless and wait untill the EC reading becomes constant. Record the result on the measurement form (see annex 1).
4. Submerge the bottle in the big bucket and fill it completely. Close the bottle and record its number on the measurement form.
5. Record the sampling date on the measurement form!

If no units of the pump station are working, the operator should be requested to start one unit for a short period. After 5 minutes of operation the actual water sampling can then be performed.

If this is impossible due to an electricity breakdown, or for any other serious reason the water sampling may be performed on the suction side of the pump station following the procedures for open drains given in the next section.

2.3.2. Water quality measurements at open drains

The complete procedure at open drains is as follows:

1. Take a sub sample with the water sampler (fig. 2-8). Put the water in the bucket, rinse the bucket, fill the bottle for 50 %, rinse the bottle and throw the water away.
2. Take 5 sub samples with the water sampler from about 1 m below the water surface. Take samples close to the left bank, in the centre and close to the right bank of the drain. Take samples in-between. To take

a sub sample the plug (fig. 2-8) is placed, the sampler lowered to app. 1 m below the water surface (indicated by a knot in the suspension line), the plug is pulled out with the stopper line and, after the air bubbles have disappeared the sampler is raised and the sampler is emptied in the bucket for the composite sample.

3. Measure the electrical conductivity (see 2.3.1).
4. Fill the bottle completely (see 2.3.1).
5. Record the measurement date on the measurement form!

If there is no access to the drain (no bridge) this sampling procedure cannot be followed. In this case the small bucket is thrown from the bank as far to the centre of the drain as is feasible and pulled back with the rope. The first bucket can be used to rinse the bottle and the second to measure the electrical conductivity and fill the bottle completely.

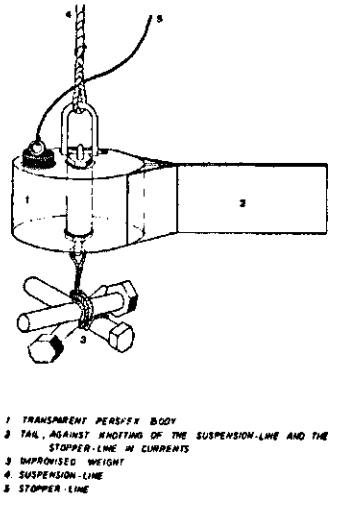


Fig. 2-8. Water sampler

2.4. CALIBRATION MEASUREMENTS (Harm Meyer)

The principle of the calibration measurements is to determine the wetted cross-section and the flow velocities, identical to the principle of the routine measurements. The calibration measurements, however, are performed with a high degree of accuracy. The instrument used for the velocity measurements is the Ott current meter, that can be mounted on rods, with depth markings, or used in combination with a torpedo-shaped suspension weight and a reel with depth indication from boats. The instrument consists of a wing that is rotated by the flowing water and the number of rotations during a certain time period is counted by the time counter instrument (fig. 2-9). The liquid display of the time counter is liable to damage from shocks and vibrations. Therefore, the time counter should be transported with care (not in the lagguge compartment of the car, but on the seats).

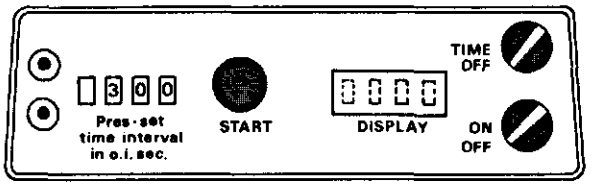


Fig. 2-9. Time counter

After each day of operation the oil in the current meter has to be changed (fig. 2-10). Use only the original Ott oil supplied by the manufacturor, because it is stable in viscosity under all circumstances and guarantees a smooth running of the propellor. Once a year the current meter calibration has to be repeated. The Hydraulic Research Institute at the Delta Barrages has excellent facilities to do this job.

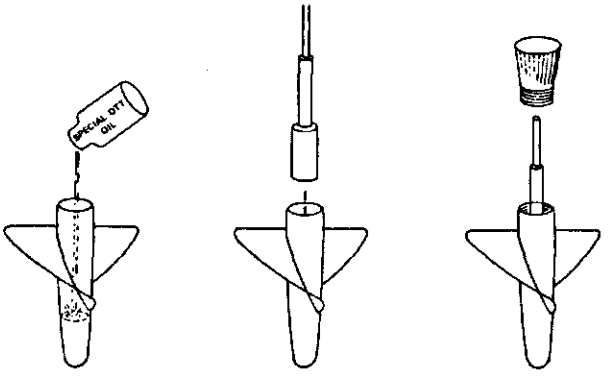


Fig. 2-10. Maintenance of the Ott current meter

2.4.1. Calibration measurements at pump stations

In order to determine the capacity curve of the pump units at least two observations of each unit have to be made: one with a small suction head and one with a big suction head. The current meter measurements are performed in the approach channels to the pump units. The measurement sections should be selected approximately in the middle of the approach channels to avoid the contractions at the beginning and at the end of these channels (fig. 2-11). The delivery channals are unsuitable for current meter measurements due to

the occurence of turbulences in the flowing water.

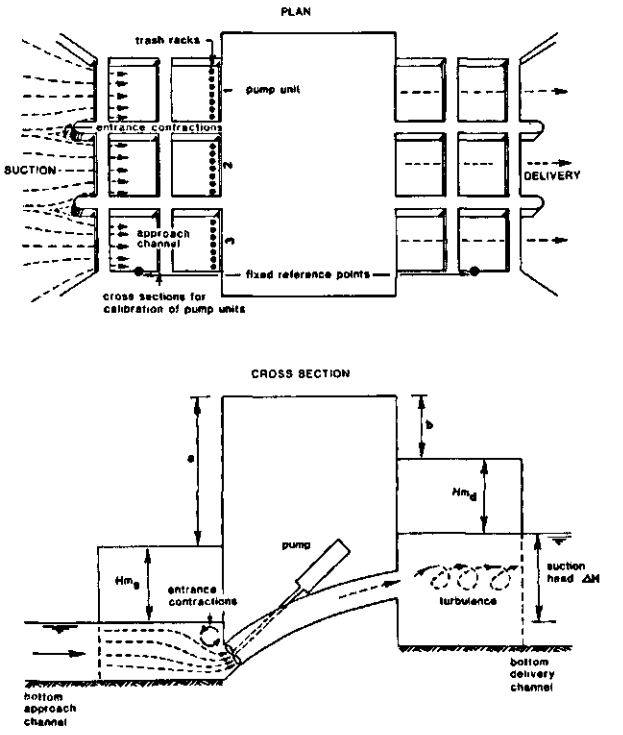


Fig. 2-11. Pump station plan and cross-section

The trash racks should be kept free of dirt and floating debris according to the normal cleaning procedures in use at the pump stations.

The complete procedure of a calibration measurement at a pump station is as follows:

1. Select the fixed reference points in the approach channel at suction side and in the delivery channel at delivery side (fig. 2-11). Mark the reference points with paint.
2. Measure the difference in elevation between both reference points, with the levelling instrument and staff. The following points should be observed:
   - assemble the instrument on the tripoïd and prepare instrument for measuring (see also chapter 2.2.);
   - place the staff at ref. point 1 and take the backward reading. Record the observation (see annex 1.6);
   - move the staff to an intermediate point and take the forward reading. Record the observation;
   - keep the staff in place and move instrument to second position. Take backward reading and record the observation;
   - move the staff to ref. point 2 and take the forward reading. Record the observation.

   Depending on the height of the intermediate section in front of the pump station and the lenght of the staff only one backward and one forward reading will be sufficient (fig. 2-12).

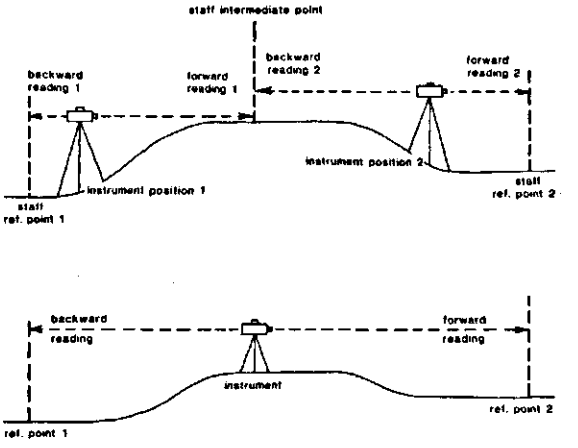


Fig. 2-12. Measurement of difference in elevation between ref. point 1 and 2

3. Explain to the pump operator the purpose and reasons of the measurements and ask his cooperation. Ask him to switch on pump unit 1.
4. Measure the width of the approach channels using a measurement tape. Record the result (see annex 1.6). Divide the width of each channel in 6 - 8 equal sections and mark these sections on the channel's cover. Fill in the headings of the measurement forms (see annex 1.6): distance from approach channel's side.
5. Assemble the current meter on rods and record the wing identification number on the measurement form.
6. Check the pre-set time interval on the counter (fig. 2-9) and record the interval on the measurement form. A time interval of 30 seconds is suitable for most measurements.
7. Measure every 15 minutes with a measurement tape the reference depth at suction side, Hm_s and at delivery side Hm_d. Record on the measurement form the distances as well as the time (see annex 1.6).
8. Start with the current meter measurements of the first pump unit. First, record the starting time

of the measurements. To save time, the measurements per measuring depth may be done for all verticals in the approach channel. The first row of measurements will be at 25 cm from the approach channel's bottom. Shift the current meter on the rod to the 25 cm position and measure the number of revolutions for each vertical. Record the results on the measurement form. Record also the total water depth in the verticals (to be read directly from the rod). Keep the rod in a proper vertical position and keep the current meter in the proper direction of flow, parallel to the approach channel's side walls.

9. The next row of measurements is at 75 cm depth from the bottom (50 cm interval between rows). The current meter has to be lifted from the water and shifted to the 75 cm position on the rod. After lowering the instrument the next row of measurements can be taken and recorded on the measurement form.
   When performing the last row of measurements the total water depth has to be checked and recorded on the measurement form.
10. Record the ending time of the measurement at the pump unit on the measurement form (see annex 1.6).
11. Switch off the first pump unit and switch on the second. Wait for a few minutes for the water levels to become constant and repeat steps 7-10 for this pump unit.
12. After finishing all pump units, discuss with the operator how many pump units can be operated simultaneously for a few hours to obtain the maximum possible suction head. Switch on the agreed amount of pump units.
13. Calibrate these pump units one by one according to step 7-10.
14. After finishing the operating units, switch off the calibrated ones and switch on the non-calibrated ones keeping the suction head approximately constant. Calibrate also these units one by one.
15. Record the date on the measurement form!

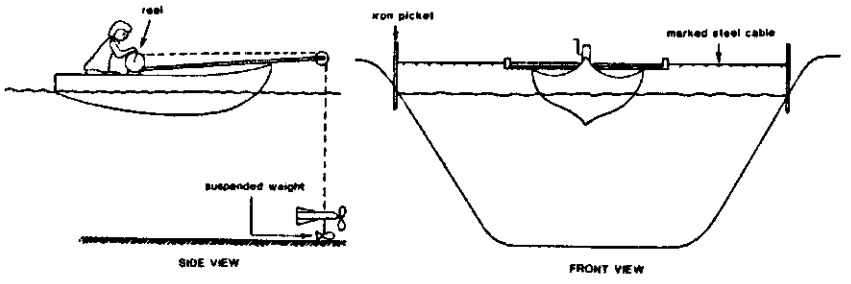


Fig. 2-13 Current meter measurements from a boat

2.4.2. Calibration measurements at open drains

At open drains the current meter measurements are performed from a boat with the current meter suspended in the water (fig. 2-13). The cross-section of the drain should be regularly and straight for some distance (say 50 m) in front of and behind the location of the calibration measurements. The location should be chosen away from the bridge, far enough to avoid disturbing turbulences in the flowing water. There is no theoretical objection against performing the calibrations from the bridge with the current meter on rods or suspended by means of a cable. Most bridges are supported by piers, however, restricting the measurement to the upstream side of the bridge (avoiding turbulencies). Not in all cases the approach channel to the bridge is straight and often the cross-section of the drain changes suddenly in the vicinity of the bridge. These and other (practical) considerations such as obstructions on the bridge itself render it in almost all cases impractical to perform calibrations from bridges.

For a reasonable Q-D relationship at least 5 to 10 calibration measurements are required, covering the full range of normal water depths (D). For the

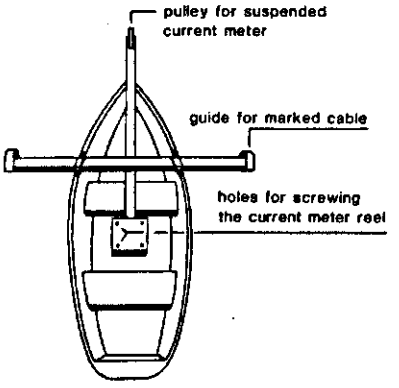


Fig.2-14. Bracket and guide construction for marked cable

measurements from the boat a bracket has been constructed (fig. 2-14) on which the current meter reel

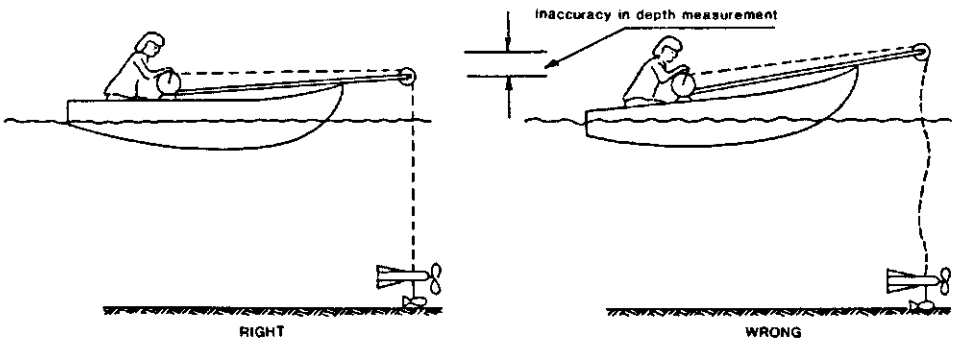


Fig. 2-15. Determination of vertical depth

with depth indication in centimeters can be screwed and the current meter with torpedo-shaped weight can be lowered with the cable guided by the pulley in front of the boat. A marked steel cable, stretched perpendicular to the direction of flow, over the cross-section (fig. 2-13) keeps the boat in the proper position during measurements.

The procedure for measuring the velocity in one vertical is as follows:

- lower the current meter by means of the reel untill the propellor is for 50 % suspended in the water. In this position the torpedo-shaped weight is located at 20 cm below the water surface (see fig. 2-13; the distance between the centre line of the propellor and the bottom side of the suspension weight is 20 cm).
- push the depth counter of the reel to zero with the current meter in this position.
- lower the current meter with the reel untill the weight touches gently the channel bottom (fig. 2-15). Do not allow the current meter and weight to rest completely on the drain bottom; this will cause the boat to rise and give a false depth measurement. This requires some experience.
- read the counter with the current meter in this position and record this depth on the measurement form (see annex 1.7.5). This is the maximum depth from the water surface at which measurements can be taken (20 cm from the drain bottom).
- measure the number of revolutions during the pre-set time interval and record the result on the measurement form.
- determine the next depth at which measurements have to be taken. Taking d' as the depth counter reading with the current meter in the lowest possible position (20 cm from the drain bottom) two possibilities occur: d'< 175 cm and d' > 175 cm (fig. 2-16).

Possibility 1 (d'< 175 cm): 4 measurements have to be taken at equal depth intervals between successive measurements with the last measurement at a depth of half this interval below the water surface. The depth interval in this case is given by: (2/7) * d' (see fig. 2-16 and annex 1.7.5.: verticals 5, 61, 65 and 66 of calibration measurements dd. 8/11/81).

Possibility 2 (d' > 175 cm): The measurements have to be taken at depth intervals of 50 cm with the last measurement at 25 cm below the water surface. This means that the first interval generally will be smaller than 50 cm. This first interval, a, consequently has to be taken smaller or equal to 50 cm, in such a way, that the total distance of the current meter to the water surface in the second position (20 + a cm from the drain bottom) equals n * 50 + 25 (see fig. 2-16; and see annex 1.7.5. for examples).

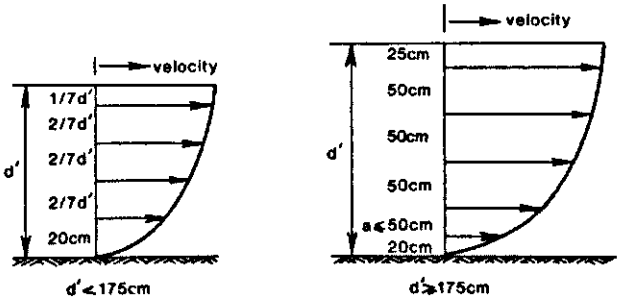


Fig. 2-16. Determination of observation depth

- record the depth's at which current meter measurements have to be made.
- move the current meter to the required positions (depth counter), measure the number of revolutions during the pre-set time interval and record the results (see annex 1.7.5.).

During the calibration measurements attention has to be paid also to the routine measurements (as a check) and to the determination of the reference depth Hm.

The complete procedure of a calibration measurement at an open drain is as follows:

1. Select a suitable cross-section for the measurements.
2. Mark the measurement cross-section perpendicular to the drain axis using the double pentagon prism. The following steps have to be performed (see fig. 2-17);

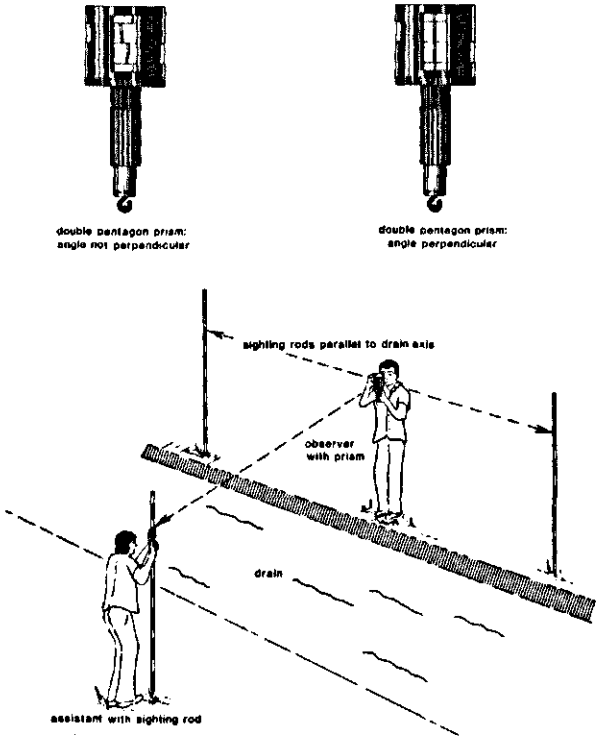


Fig. 2-17. Use of the double pentagon prism

- place two red and white painted sighting rods upstream and downstream of the envisaged cross-section parallel to the drain axis on one side of the drain;
- move one person with a sighting rod to the opposite side of the drain (see 'assistant' in fig. 2-17);
- keep the double pentagon prism in the line between the two sighting rods and let the assistant move left or right untill the image through the prism (see fig. 2-17) forms a straight line. The angle is now perpendicular;
- hammer a steel picket into the soil exactly at the position of the prism and one on the location of the assistants' sighting rod.

3. Assemble the bracket and guide construction (fig. 2-14) and fix it to the boat. Assemble the current meter with suspension weight and reel and fix it to the bracket. Record the current meter wing identification on the measurement form (see annex 1.7.5.).
4. Attach the marked steel cable to the pickets on both sides of the drain. The cable should be pulled through the guides attached to the boat (see figs 2-13 and 2-14).
5. Stretch the cable sufficiently to hang free from the water surface and to allow floating water plants and debris to pass unobstructed, using the pulley combination (fig. 2-18) that increases the exerted power considerably.

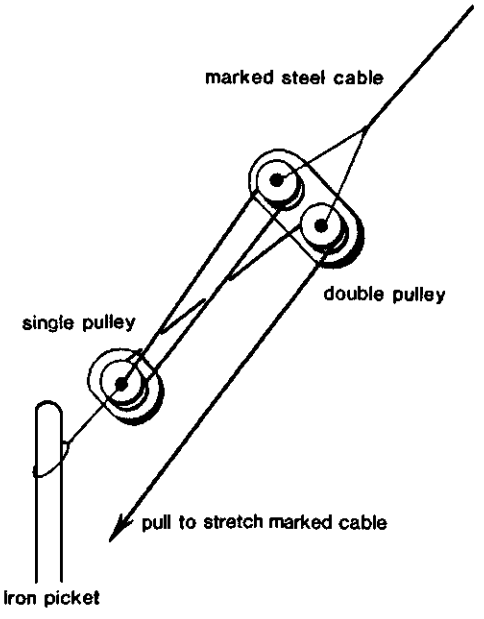


Fig. 2-18. Stretching the marked steel cable with the pulley combination

6. Perform the routine measurements from the bridge (see also chapter 2.2):
   - Hm
   - float measurements
   - pendulum meter measurements.

   Record the time and the measurement results on the measurement form (see annex 1.7.5).
7. Repeat the Hm and the pendulum measurements every 30 min during the course of the calibration measurements. Sudden changes in the flow regime may be signalled by these measurements. Record measurement

results together with the time at which they were performed.

8. Select the interval between the verticals that will be measured in such a way that 15 to 20 verticals result. Take the first vertical at half this interval from the point where the water level is zero. Record these details on the measurement form (see annex 1.7.5): distance from right/left bank facing the bridge/drain of verticals; water level zero at .... meter.
9. Check the interval timer and write the selected interval on the measurement form. In general an interval of 30 seconds will give reasonably accurate results. Record this interval on the measurement forms. Record the starting time of the measurement.
10. Move the boat to the first vertical and measure the velocity distribution following the procedure given for the velocity measurements. Record the results on the measurement form.
11. Move the boat to the next vertical and measure according to step 10.
12. After finishing all 15-20 verticals record the ending time and perform routine measurements at the bridge:
    - Hm
    - float measurements
    - pendulum meter measurements.
13. Dis-assemble and clean all the equipment used.
14. Record the date on the measurement form!

3. LABORATORY ANALYSIS (Eng.Laila El Sissy)

The laboratory analyses performed in the DRI laboratory are all well-established and well-known methods and procedures.

The main laboratory equipment in use for the chemical water sample analyses are the following:

- electrical conductivity apparatus with automatic temperature correction;
- pH-apparatus;
- titration equipment: balances, burettes, pipettes, etc.
- flame photometer;
- Kjehdahl distillation apparatus;
- atomic adsorption apparatus;
- spectrophotometer.

Some general recommendations with respect to the laboratory work will be made here:

- Use clean glassware. Glassware should be cleaned by washing in hot soap suds and afterwards rinsing with tap water and destilled water.
- Filter the water samples. This is important when the sample contains colloïdal contaminations. Only in clear samples the colour changes of the indicators can be observed properly.
- Organise a monthly cleaning and checking operation of all the equipment in the laboratory. On the same day standard solutions can be prepared and cell constants checked (EC!). Compare the new standard solutions with the previous ones.
- Adjust the normality of titration solutions by more than one laboratory worker and average the normalities found.
- Prepare standard solutions with pure destilled water.
- Start each series of analysis with a blank sample of the destilled water and reagents to check both on impurifications and — if necessary — adjust the results.
- Use pipettes of the proper capacity.
- Water sample bottles should be stored in a cool place in the laboratory (outside the sun!) and should be kept closed.

The general procedure for the laboratory analyses of water samples is as follows:

1. The first office day following the routine measurement field trip the boxes with water samples are transported from the car to the office. A letter to the laboratory specifying the bottle number, the sample collection location identification number and full name and the date of collection is prepared.

2. The samples, accompanied with the letter are transferred to the laboratory. On the letter the laboratory identification numbers are assigned to the water samples.
3. The samples are transferred to the electrical conductivity and acidity table (fig. 3-1).

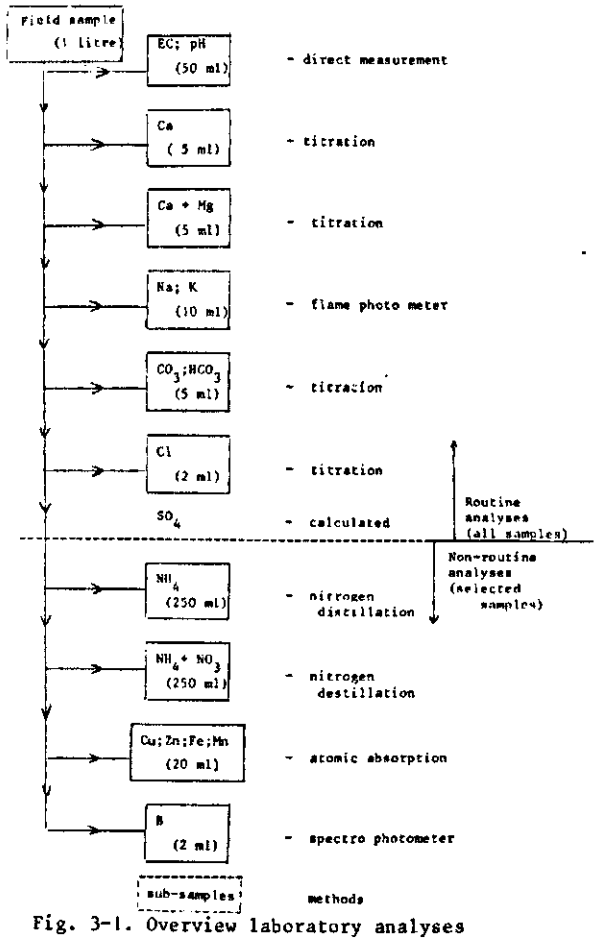


Fig. 3-1. Overview laboratory analyses

A data sheet is prepared with the date of submittance to the laboratory, the bottle number, the laboratory number, the sample collection location identification number and the full name of this location. Subsamples of app. 50 ml are taken and placed in a glass beaker in front of the bottles (with identification number). In the subsamples the EC and pH are measured and recorded on the data sheet. This data sheet is then transferred to the head of the chemical department of the laboratory.

4. The samples are transferred to the carbonate and bi-carbonate table. A data sheet is prepared. Subsamples of 5 ml are pipetted into small beakers, placed in front of the bottles. By titration the CO_3^{2-} and HCO_3^- concentrations are determined. The results are recorded on the data sheet and the data sheet transfered to the department head.
5. The samples are transferred to the calcium and magnesium table (see fig.3-1). A data sheet is prepared. Subsamples of 5 ml are taken by a volumetric pipette and placed in porcelain disks in front of the bottles for the Ca^{2+} determination and in Erlenmeyer flasks for the Ca^{2+}+Mg^{2+} determination. By titration the Ca^{2+} and the Ca^{2+}+Mg^{2+} concentrations are measured. The results are recorded on the data sheet, the Mg^{2+} concentrations calculated and the data sheet is transferred to the department head.
6. The samples are transfered to the sodium and potassium table. A data sheet is prepared. Subsamples of app 10 ml are taken and placed in front of the bottles. With the flame phonometer and a sodium filter the Na^+ readings are taken. The subsamples are placed again in front of the bottles and the readings recorded on the data sheet. Next, a potassium filter is mounted in the flame photometer and the K^+ readings are obtained and recorded on the data sheet. Using the calibration graphs or tables of Na^+ and K^+ the readings are transformed into concentrations on the data sheets and the sheets transferred to the department head.
7. The samples are transferred to the chloride table. A data sheet is prepared. Subsamples of 2 ml are pipetted and placed in Erlenmeyer flasks in front of the bottles. By titration the Cl^- concentration is determined and recorded on the data sheet. The data sheet is transferred to the department head.
8. If no non-routine analyses have to be performed the remainder of the water samples are stored in a cool place until the department head has checked the laboratory analyses and orders emptying and cleaning of the sample bottles.
9. If non-routine analyses have to be performed the samples are transferred to the nitrogen department. A data sheet is prepared. Subsamples of 250 ml are taken with a graduated glass cilinder and placed in the Kjeldahl flasks and by distillation the NH_4^+ concentration is determined. The results are recorded on the data sheet. Next subsamples of 250 ml are taken for the determination of total inorganic nitrogen expressed as NH_4^+ concentration. By subtraction the NO_3^- concentration is found. The results are recorded on the data sheet and the data sheet transferred to the department head.
10. The samples are transferred to the atomic adsorption table. A data sheet is prepared. The atomic adsorption spectrophotometer is prepared for copper determination (specific lamp and specific wave length). Take subsamples, measure the Cu concentration and record the results on the data sheet. Proceed next to zink, iron and mangnese. Measure the concentration, record the

results and transfer the data sheet to the department head.

11. The samples are transferred to the spectrophotometer table. A data sheet is prepared. Subsamples of 2 ml are pipetted and the Boron concentration is determined. Record the results and transfer the data sheet to the department head.
12. The remainder of the water samples are stored in a cool place until the department head has checked the analyses and orders emptying and cleaning of the bottles.
13. The results are checked by the head of the chemical analysis department. A data sheet with results of the routine analyses is prepared (EC, pH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CO_3^{2-}, HCO_3^{-}, Cl^{-}) from the 5 pertinent data sheets. The SO_4^{2-} concentration (in meq/l) is calculated as the difference between $Ca^{2+} + Mg^{2+} + K^{+} + Na^{+} - (CO_3^{2-} + HCO_3^{-} + Cl^{-})$. The consistency of the chemical analysis with the measured electrical conductivity is checked with the HP 97 programme 'Water quality processing' (chapter 4.2). If the data are not consistent a second analysis is ordered by the department head and the samples are transferred to the EC and pH table and the steps 3 to 8 are followed again.
    The non-routine analysis data are recorded on a seperate data sheet.
14. The data sheets with checked routine analysis results are copied and a copy given to the field observor. He checks the electrical conductivity measured in the laboratory against the EC measured in the field. If deviations for all samples are found the EC meter used in the field can be checked against the laboratory EC meter. Individual sample deviations may be detected and if so, the department head is informed and the samples in question are analysed again (steps 3-8 of the procedure.
15. The measured Na^{+} concentration and the Cl^{-} concentration are checked against the electrical conductivity using the relationships based on the data of the previous observation year (see chapter 5.2) using the empirial EC-Na and EC-Cl relationships (fig. 3-2). If the (EC, Na) and/or the (EC,Cl) data pair is outside the area enclosed by the enveloping curves the sample has to be analysed again (steps 3-8 of the procedure).
16. After all samples are checked the department head is notified and the water bottles are emptied and cleaned and can be used for next sampling campaigns.

In the following sections the identified laboratory determinations will be treated in detail.

3.1. Electrical conductivity and acidity

The EC and pH are measured in the same subsample of approximately 50 ml.

The procedure for the EC measurement is as follows:

Apparatus

- glass beakers, 50 or 100 ml
- conductivity meter (automatic temperature correction)
- conductivity cell (pipette type)
- thermometer, covering room temperature.

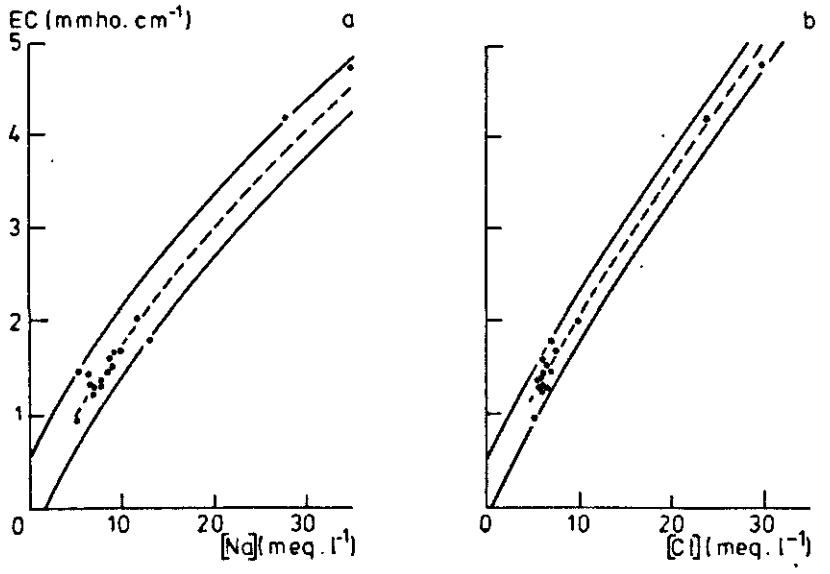


Fig. 3-2. Example of an EC-Na relation (2a) and an EC-Cl relation (2b) with enveloping curves based on routine measurements

Reagents

- potassium chloride, 0.05 M
  Dissolve 3.728 gr dry KCl in 1 ltr of distilled water
- potassium chloride, 0.01 M
  Dilute 50 ml of the 0.05 M solution to 250 ml with distilled water.

Procedure

- General
  + rinse the conductivity cell (pipette type) 3 times with distilled water
  + rinse the cell with the sample to be measured
  + fill the cell with the sample to be measured
  + select the proper measurement range and record the range factor, R
  + take the scale reading, S, and record result.
- Cell constant (whenever required, but at least monthly)
  + measure and record the temperature, t, in the 0.05 M KCl solution
  + measure and record the range factor, R, and scale reading, S, in the 0.05 M solution
  + measure and record the temperature, t, range factor, R, and scale reading, S, in the 0.01 M solution.
- Watersample
  + measure and record the range factor, R, and scale reading, S, in the water sample.

Calculations

- Cell constant
  + take the reference conductivity value, U, of the 0.05 M and 0.01 M KCl solutions at the measured temperature, t (table 3-1)
  + calculate the cell constant, C:

$$C = \{ \left(\frac{U}{S * R}\right)_{0.05M} + \left(\frac{U}{S * R}\right)_{0.01\ M} \}/2$$

  + record the cell constant with a sticker on the instrument. Record also the date of the cell constant determination.
- Watersample
  + record the cell constant on the data sheet
  + calculate the EC:

$$EC = S * R * C$$

  and record the result on the data sheet with two decimals behind the decimal point when expressing the EC in mmho/cm.

Temperature in °C	0.01 M	0.05 M
15	1.147	5.404
16	1.173	5.527
17	1.199	5.651
18	1.225	5.775
19	1.251	5.889
20	1.278	6.024
21	1.305	6.149
22	1.332	6.275
23	1.359	6.402
24	1.386	6.529
25	1.413	6.656
26	1.440	6.784
27	1.468	6.912
28	1.496	7.041
29	1.524	7.170
30	1.552	7.300
31	1.580	7.430
32	1.609	7.561
33	1.637	7.692
34	1.666	7.824
35	1.695	7.956

Table 3-1. Specific conductivity values of potassium chloride solutions (mmho cm^{-1})

The procedure for the pH measurement is as follows:

Apparatus

- glass beakers, 50 or 100 ml
- pH meter
- glass electrode
- reference calomel electrode, with saturated KCl solution
- plastic wash bottle.

Reagents

- buffer solution pH 4 and pH 6.85.

Procedure

- calibrate the meter with the buffer solutions
  + weekly: 1. Adjust the meter to 6.85 with the electrode in the pH 6.85 buffer;
    2. Adjust the meter to 4 with the electrode in the pH 4 buffer;
    3. Repeat steps 1 and 2 until no deviations from the buffer occur.
  + daily : Step 1 of the weekly calibration described above
- rinse the electrode thoroughly with distilled water
- insert the electrode in the subsample and record the pH to the nearest 0.1 unit
- rinse the electrode thoroughly and continue with the next subsample
- after finishing the measurements the electrode

should be placed in distilled water.
- ensure that the reference electrode always contains saturated potassium chloride solution in contact with solid KCl crystals
- store the two electrodes in distilled water when not in use.

3.2. Calcium and magnesium

Calcium and magnesium are determined by titration with ethylene diamine tetra äcetate (versenate).

The procedure is as follows:

Apparatus

- volumetric pipette, 5 ml
- porcelain disks, 5-10 cm wide
- micro buret, 10 ml
- Erlenmeyer flasks, 125 ml.

Reagents

- A. Ammonium chloride - ammonium hydroxide buffer solution.
  Dissolve 67.5 gr of NH_4Cl in 570 ml of concentrated NH_4OH solution and add distilled water till 1 litre.
- B. Sodium hydroxide, 4 M.
  Dissolve 160 gr of NaOH in 1 litre of distilled water.
- C. Standard calciumchloride solution, 0.005 M.
  Dissolve 0.500 gr of pure calcium carbonate (calcite crystals) in 10 ml hydrochloric acid of 3 M and dilute with distilled water to 1 litre exactly. The $CaCO_3$ has to be dried 2 hours at 400 °C and has to be stored above water-free $CaSO_4$.
- D. Eriochrome black T indicator.
  Dissolve 0.5 gr of eriochrome black T and 4.5 gr of hydroxylamine hydrochloride in 100 ml of ethanol 95 %.
- E. Ammonium purpurate indicator.
  Thoroughly mix 0.5 gr of ammonium purpurate with 100 gr of powdered potassium sulphate.
- F. Ethylene diamine tetra äcetate (versenate) solution, appr. 0.005 M.
  Dissolve 1.86 gr of pure disodium dihydrogen ethylene diamine - tetra äcetate ($Na_2EDTA.2H_2O$) and 0.05 gr of magnesium chloride hexa hydrate in distilled water and dilute to a volume of 1 litre. Store the standard solution in a polyethylene bottle.

Procedure

- Molarity of versenate solution for calcium titration
  + clean the pipette with distilled water, rinse with the standard solution and take a 5 ml sample of the $CaCl_2$ standard solution (reagent C).
  + pipet 5 ml in a porcelain disk and 5 ml in an Erlenmeyer flask and dilute with distilled water to a volume of appr. 25 ml.
  + add 5 drops of reagent B and appr. 50 mg of the indicator E to the porcelain disk.
  + titrate with the versenate solution (reagent F) with the 10 ml microburet. The versenate should be added at a rate of one drop every 5 to 10 seconds when close to the titration end point. The colour change is from organgered to purple.
  + record the volume of versenate used: V_{NC} ml.
- Molarity of versenate solution for calcium + magnesium titration*
  + add 10 drops of reagent A and 3 to 4 drops of the indicator D to the Erlenmeyer flask.
  + titrate with the versenate solution (reagent F) with the 10 ml microburet. The colour change is from wine-red to blue.
  + record the volume of versenate used: V_{NM} ml.
- Calcium determination
  + clean the 5 ml volumetric pipette, rinse with the water sample, take a 5 ml subsample in a porcelain disk and a 5 ml subsample in an Erlenmeyer flask.
  + follow the titration procedures for the versenate molarity determination for calcium titration.
  + record the volume of versenate used: V_C ml.
- Calcium and magnesium determination
  + follow the titration procedures for the versenate molarity determination for the calcium + magnesium titration.
  + record the volume of versenate used: V_M ml.

Calculations

- the versenate molarity for the calcium titration M_C is found:

$$M_C = \frac{\text{pipette volume} * M(CaCl_2)}{\text{versenate volume}} = \frac{0.025}{V_{NC}}$$

*) The molarity of the versenate solution for the Ca+Mg determination is generally 3 to 5 % higher than the molarity for the Ca determination

- the calcium concentration in meq/l is calculated with:

  $Ca^{2+} = 200\ V_C M_C * 2 = 10\ V_C/V_{NC}$

- the versenate molarity for the calcium + magnesium titration M_M is found:

  $$M_M = \frac{0.025}{V_{NM}}$$

- the calcium + magnesium concentration in meq/l is calculated with:

  $Ca^{2+} + Mg^{2+} = 10\ V_M/V_{NM}$

- the magnesium concentration then follows:

  $Mg^{2+} = 10\ \{ V_M/V_{NM} - V_C/V_{NC}\}$

3.3. Sodium and potassium

The sodium and potassium concentrations are determined by spraying the samples directly into the flame of the flame photo meter and measuring the amount of light emittance of specific wave length. These scale readings are adjusted with a standard graph.

The measurement procedure is as follows:

Apparatus

- a flame photo meter with sodium and potassium filter
- small beakers or sample holders
- volumetric pipettes 2, 5, 10, 20 ml
- graduated volumetric flask, 100 ml.

Reagents

- sodium chloride, 0.1 M
  Dissolve 2.9224 gr dry NaCl and add distilled water to 500 ml exactly.
- sodium chloride standard solutions, 0.2, 0.4, 0.6, 0.8, 1, 2, 4, 6, 8, 10, 15 and 20 meq Na^+ per litre.
  Dilute 2, 4, 6, 8, 10, 20, 40, 60, 80, 100, 150 and 200 ml of the 0.1 M NaCl solution with distilled water, each to 1 litre exactly.
- potassium chloride, 0.05 M
  Dissolve 1.864 gr dry KCl and add distilled water to 500 ml exactly.
- potassium chloride standard solutions, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.8, 1.0, 1.2, 1.5, 2, 3, 4 and 5 meq K^+ per litre.
  Dilute 2, 4, 6, 8, 10, 12, 16, 20, 24, 30, 40, 60, 80 and 100 ml of the 0.05 KCl solution with distilled water, each to 1 litre exactly.

Procedure

- Determination of standard graphs (whenever required but at least monthly)
  + activate the flame photo meter and put the sodium filter for the sodium curve and potassium filter in case of potassium curve determination.
  + spray alternatively distilled water and the NaCl or KCl standard solution with the maximum concentration (20 meq/l for NaCl and 5 meq/l for KCl) into the flame and operate the sensitivity controls until the reading of the distilled water is zero and the reading of the standard solution is 100 (maximum reading).
  + spray the standard solutions one after the other into the flame and record the scale readings.
- Measurement of watersamples
  + take small subsamples from the bottles
  + activate the flame photo meter and insert the pertinent filter.
  + spray alternately distilled water and the standard solution with max. concentration into the flame and operate the sensitivity controls of the instrument until the scale reading of the distilled water is zero and of the standard solution 100.
  + spray one by one the watersamples into the flame and record the scale reading.
  + if the reading is outside the scale (more than 100), pipet 10 ml of watersample into a graduated glass cylinder and dilute with distilled water until 100 ml exactly and mix. Spray the dilution in the flame, record the scale reading and record the dilution factor (10). If necessary, the dilution procedure can be repeated (dilution factor 100!)
  + check the performance of the photo meter after every 5 measurements by spraying the blank and the highest standard solution. Adjust the sensitivity as necessary. If the reading of the highest standard has changed considerably inspect the nebulizer for clogging and clean if necessary.

Calculations

- Standard graphs
  + prepare a graph on mm paper (fig. 3-3) for both the Na^+ and K^+ standard solution observations.
  + plot the concentration and scale readings of the standard solutions.
  + draw a curve through the observations using a 'french curve' (fig. 3-3).
  + record the date of the standard curve determina-

tion on the graph, leave a copy with the apparatus and transfer the original to the department head.

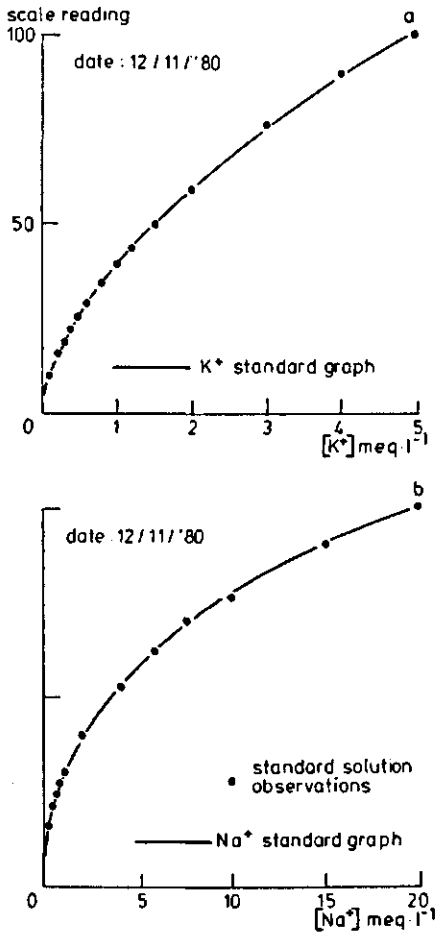


Fig. 3-3. Examples of a Na^+(a) and K^+(b) flame photometer standard graph

- Water samples
  + check the date of the standard graph
  + use the curve's to find the Na^+ and K^+ concentrations, and record the results. Multiply with the dilution factor, if applicable.

3.4. Carbonate and bicarbonate

Carbonate and bicarbonate are determined in one titration procedure in the same sub-sample. The procedure is as follows:

Apparatus

- volumetric pipette, 5 ml
- glass beakers, small
- microburet, 10 ml.

Reagents

- A. Phenolphthalein indicator, 1 % in 60 % ethanol
- B. Methyl orange indicator, 0.01 % in water
- C. Hydrochloric acid, appr. 0.01 M. The molarity of the of the HCl solution must be known exactly (standardized) by titration with silver nitrate (chapter 3.5): M_C
- D. Buffer solution pH 4.1
  Take a small volume (250 ml) of sodium acetate 0.1 M, add 1 M HCl until the pH, measured with a pH meter, equals 4.1.

Procedure

- rinse a 5 ml volumetric pipette with distilled water, rinse with the water sample and transfer into a small glass beaker.
- add one drop of indicator A
- if the solution turns pink, titrate with HCl (reagent B) with a 10 ml micro buret until the colour just disappears. Add reagent C drop-wise at 5 seconds intervals. Record the volume of reagent used: V_C; If the solution did not turn pink $V_C = 0$!
- add 2 drops of indicator B
- titrate with HCl (reagent C) drop-wise at 5 seconds intervals to the first orange colour. Record the volume of reagent C used: V_B.
- compare the colour of the solution at titration end-point with the colour of 5 ml of reagent D with 1 drop of indicator B.

Calculations

- the CO_3^{2-} concentration in meq/l can be calculated with:

$$CO_3^{2-} = \frac{1000\ M_C\ 2\ V_C}{\text{sample volume}} = 400\ M_C V_C$$

- the HCO_3^- concentration in meq/l is calculated with:

$$HCO_3^- = \frac{1000\ M_C V_B}{\text{sample volume}} = 200\ M_C V_B$$

3.5. Chloride

The chloride concentration is determined by titration with silver nitrate following the procedure:

Apparatus

- volumetric pipette, 2 ml
- Erlenmeyer flasks, 100 or 150 ml
- microburet, 10 ml

Reagents

- potassium chromate, 5 % solution
  Dissolve 5 gr of potassium chromate in 50 ml of distilled water and add 1 M silver nitrate drop-wise until a slight permanent red precipitate is produced. Filter and dilute with distilled water to 100 ml.

- sodium chloride solution 0.02 M
  Dissolve 1.169 gr of NaCl (dried at 300 °C) in about 100 ml of distilled water and dilute to exactly 1 litre.
- silver nitrate, 0.005 M.
  Dissolve 0.8495 gr of silver nitrate in CO_2-free distilled water and dilute to exactly 1 litre. Store the solution in a brown bottle, away from light.
  The molarity must be known exactly (normalized) by titration of the NaCl standard solution, M_S.

Procedure

- pipet 2 ml of the water sample with a volumetric pipet in an Erlenmeyer flask.
- add 10 ml of distilled water
- add 4 drops of potassium chromate
- titrate with silver nitrate from a 10 ml micro buret under a bright light while stirring until the first permanent reddish-brown colour. Place a white paper below the Erlenmeyer Record the volume of Ag NO_3 used: V_C
- repeat the same procedure with 10 ml of distilled water (blank). Record the volume of Ag NO_3 used: V_B

Calculation

- the Cl^- concentration in meq/l is calculated with:

$$Cl^- = \frac{1000\ (V_C - V_B)\ (\text{Molarity } AgNO_3)}{\text{sample volume}} = 500(V_C - V_B)M_S$$

3.6. Sulphate

The sulphate concentration is not measured, but calculated as the difference between cat-ions (Ca^{2+}, Mg^{2+}, Na^+ and K^+) and the other anions (CO_3^{2-}, HCO_3^- and Cl^-).

3.7. Nitrogen

Ammonium is determined by distillation and titration; nitrate by reduction to ammonium and measuring total nitrogen in the form of ammonium. The procedure is as follows:

Apparatus

- Kjeldahl distillation apparatus with 500 ml Kjeldahl flasks
- volumetric pipette, 25 ml
- conical receiver flasks, 500 ml
- burets, 25 ml
- graduated glass cylinder, 250 ml

Reagents

- sodium hydroxide, 40 %.
- bromine cresol green (0.5 %) and methyl red (0.1 %) mixed indicator solution..
  Dissolve 0.5 gr of bromine cresol green and 0.1 gr of methyl red in 100 ml of 95 % ethanol. If the solution is pink (pH < 4.2), adjust the solution with diluted NaOH solution to the bluish purple mid-colour, characteristic for pH = 4.5. If the solution is bluish-geen (pH > 4.9), adjust with diluted HCl solution to the bluish-purple mid-colour.
- boric acid, 4 %.
  Dissolve appr. 40 gr of H_3BO_3 in 1 litre of distilled water containing 5 ml of the mixed indicator solution.
- HCl solution, approximately 0.01 M.
  Standardized solution with molarity M_C.
- Davarda's alloy (Cu 50 %; Al 45 %; Zn 5 %).
  Mix 10 gr of Cu powder, 9 gr of Al powder and 1 gr of Zn powder thoroughly.

Procedure

- take 25 ml of the 4 % boric acid stock solution and add 4 drops of the mixed indicator.
- titrate with the HCl solution until the bluish-purple colour weakens towards pink. Record the volume of HCl used for this blank titration: V_B
- take 25 ml of the boric acid stock solution with a 25 ml pipette into the 500 ml conical receiver flask and add 4 drops of the mixed indicator.
- place the glass receiver tube of the distillation apparatus in the receiver flask with the end of the tube well below the surface of the boric acid.
- open the water tap to operate the cooling system of the distillation apparatus.
- take a 250 ml subsample of the sample to be analized , using the graduated glass cylinder into the Kjeldahl flask. Place the flask on the distillation stand and check the proper fitting with the condensor connection.
- for ammonium:
  -Keep the Kjeldahl flask with the watersample at an angle of 45° and carefully add appr. 10 ml of the 40 % NaOH solution to the flask. Pour the NOH in the flask in such a way that it runs down the neck to the bottom of the flask without mixing.
- for total nitrogen:
  -add 2 gr of Davarda's alloy and 10 ml of the 40 % NaOH solution to the Kjeldahl flask, taking the same precautions as for the ammonium determination.
  -attach the Kjeldahl flask to the distillator, mix the solution by swirling and lighten the burner.

-the flask is placed on the distillation still and heated.

- for ammonium:
- - continue the distillation until appr. 150 ml has been distilled.
- for total inorganic nitrogen:

-continue the distillation until the Kjeldahl flask is nearly dry (appr. 225 ml distilled).

-disconnect the receiver flask and tube from the distillation apparatus to prevent the sucking back of the distillate.

- titrate the remaining boric acid in the receiver flask with the 0.01 M HCL solution. At the titration nd point the bluish-purple colour just disapprears; one drop in excess turns the solution pink.

-record the volume of 0.01 M HCl used.

- for ammonium: V_A
- for total inorganic notrogen: V_T

Calculations

- Ammonium

The ammonium concentration in meq/l can be calculated with:

$$NH_4^+ = 1000 \cdot \frac{(V_B - V_A)\ M_C}{\text{sample volume}} = 4\ (V_B - V_A)\ M_C$$

- Total nitrogen

The total inorganic nitrogen content, expressed as ammonium concentration in meq/l is calculated with:

$$(NH_4^+)_T = 4\ (V_T - V_A)\ M_C$$

For the calculation of the nitrate concentration in meq/l the NH_4^+ concentration of the water sample has to be subtracted from this amount:

$$NO_3^- = 4\ (V_T - V_B)\ M_C$$

3.8. Copper, zinc, iron and manganese

For the determination of copper, zinc, iron and manganese the atomic adsorption spectro photometer is used. For each element a specific lamp has to be fitted in the instrument with a specific emitting wave length. Using standard solutions the instrument prepares an internal calibration curve.

The sample is inserted in the apparatus and a direct reading of the concentration (in ppm) is automatically obtained.

The measurement procedures are properly described in the catalogue if the instrument.

Reagents

- standard copper solution, 500 ppm, in 0.1 M hydrochloric or sulphuric acid.
  Dissolve 1.9647 gr of copper sulphate, $CuSO_4.5H_2O$, in appr. 500 ml distilled water. Add 20 ml 5M hydrochloric or sulphuric acid and dilute with distilled water to 1 litre exactly.
- standard zinc solution, 500 ppm.
  Dissolve 0.500 gr of powdered zinc metal in a small volume of 1 M HCL and dilute to 1 litre exactly with 1 % HCl solution.
- standard zinc solution, 1 ppm.
  Dilute 1 ml of the standard 500 ppm zinc solution to 500 ml exactly with distilled water.
- standard iron solution, 100 ppm.
  Dissolve 0.7023 gr of $Fe(NH_4)_2\ (SO_4)_2 .\ 6H_2O$ in a small volume of distilled water to which 20 ml of 0.6 N HCl is added. Dilute to 1 litre exactly with distilled water.
- standard iron solution, 5 ppm.
  Dilute 5 ml of the standard 100 ppm iron solution to exactly 100 ml with distilled water.
- standard manganese solution, 1000 ppm.
  Dissolve 2.877 gr of potassium permanganate in appr. 250 ml of distilled water to which 10 ml of concentrated sulphuric acid has been added. Boil for a few minutes and carefully add 12 gr of sodium sulphite crystals, $Na_2SO_3.7\ H_2O$, to reduce the permanganate ion to the divalent manganese.Boil again to remove the sulphur di oxide, cool, and dilute to exactly 1 litre with distilled water.

3.9. Boron

Boron is determined with the spectro phonemeter by preparing a standard curve relating the instrument readings with concentration using a series of standard solutions.
The procedure is as follows:

Apparatus

- spectro photometer
- burettes, 100 ml
- boron free Erlenmeyer flaskes, 50 ml
- pipette, 2 ml.

Reagents

- A. Hydrochloric acid, concentrated.
- B. Sulphuric acid, concentrated.
- C. Carmine solution, 0.025 % in sulphuric acid.
  Stir 0.125 gr of powdered carmine rapidly into 500 ml of concentrated sulphuric acid. Store this solution immediately in a boron-free glass bottle.

- D. Standard boric acid solutions.
  - + 1. Boric acid, 500 ppm boron.
    Dissolve 2.860 gr of boric acid, H_3BO_3, in distilled water and dilute to 1 litre exactly.
  - + 2. Boric acid, 50 ppm boron.
    Diltue 25 ml of the 500 ppm solution (reagent D 1) to 250 ml exactly.
  - + 3. Boric acid standards containing 1, 2, 3, 4 and 5 ppm boron.
    Dilute 5, 10, 15, 20 and 25 ml of the 50 ppm solution (reagent D 2) each to 250 ml exactly with distilled water.

Procedure

- pipet 2 ml of distilled water in a 50 ml Erlenmeyer flask
- pipet 2 ml of the standard solutions (reagent D3) with 1, 2, 3, 4 and 5 ppm boron in 50 ml Erlenmeyer flasks
- pipet 2 ml of the watersamples to be analyzed into 50 ml Erlenmeyer flasks
- add 2 drops of reagent A, 10 ml of reagent B (using the burette, adding B slowly while shaking the Erlenmeyer flask) Close the flasks and allow to cool
- add 10 ml of reagent C using the 100 ml burette, mix well and leave the Erlenmeyer flasks for 1 hour to develop the colour
- determine the percentage of transmittance of all samples prepared of the 585 mμ wavelength with the spectro photometer. Record the scale readings.

Calculations

- prepare the standard graph by plotting the scale readings of the standard series with 0, 1, 2, 3, 4 and 5 ppm boron against the concentration on millimeter paper and draw a curve through these observations.
- converse the scale readings of the watersamples using the standard graph to concentrations (in ppm). Record the results.

4. DATA PROCESSING

In this chapter a description of the data processing methodology in use at the DRI for the routine measurement programme (for the fortnightly measurement schedule) is presented. Upon increasing the measurement frequency by automation and complete calibration of the observation network, the methods used will need reconsideration. Possibly (parts of) the methods presently in use can still be used in the future for checking the proper functioning of the field equipment installed and the validity of the calibration relations established.

Together with the data processing methodology the HP 97 calculator programmes that have been developed at DRI to facilitate the calculations will be treated. Both will be illustrated with calculation examples, for which the data have been taken from annex 1.

It is considered important that the data processing follows the data collection campaigns as soon as possible. Only under this condition it is possible for the field observor to correct the possibly occuring spurious errors, or gaps in the field measurement forms. If too much time elapses after the field campaign and more campaigns may have succeeded, the observor's memory will have been erased to a great extent. The same reasoning holds for the watersamples. They should be delivered soonest to the laboratory after returning from the field. The exchange of sample bottles of two or more locations may be detected if the sampling campaign is still fresh in the memory.

The number of digits of data carried through the calculations should be restricted to the significant ones. If the number 1.8125 has two significant digits, it should be used with two digits in the calculations: 1.8. The meaning of this is that the true value of the number given by 1.8 is between 1.75 and 1.85. If zero's are included in the significant digits, they should be recorded. The number 1.800 (4 significant digits) should be recorded as such, and not as 1.8, because the true value of the number is between 1.7995 and 1.8005, which is much more accurate than the accuracy of the notation 1.8 (between 1.79 and 1.85). When performing calculations involving multiplication, division and powers of numbers, the final result can have no more significant digits than the numbers used with the fewest number of significant digits. The multiplication (73.24 * 4.52) should not be recorded as 230.9448, but as 231. In performing additions and substractions of numbers, the final result has no more significant

digits after the decimal point than the number with the fewest significant digits after the decimal point. The substraction (100 - 3.72) should not be recorded as 96.38, but as 96. This means that frequently calculation results will have to be rounded to the nearest unit of the last significant digit. The number 3.52 should be rounded to 3.5 if two digits are significant and the number 3.497 to 3.50 if three digits are significant, because 3.497 is closer to 3.50 than to 3.49. If the last significant digit is followed by the digit 5 the number cannot be rounded to the nearest unit of the significant digit. The number 2.75 with . significant digits is as close to 2.7 as it is to 2.8! By convention this type of numbers should be rounded to the nearest even integer preceding the digit 5. The number 2.75 should be rounded to 2.8 and the number 1.65 to 1.6. For reasons of uniformity these procedures are not strictly obeyed in the calculation methodology in use at DRI. The number of digits after the decimal point are kept constant for the different measured and calculated data (see annex 2).

For all calculations and consistency analyses (see next chapter) that have to be performed for the measurements collected during a specific year, the last set of observations of the preceding year as well as the first set of observations of the succeding year have to be included for reasons of data presentation (treated in chapter 6).

After finishing the data processing of a complete observation year (including the preceding and succeeding date) and recording the results in the proper format (see annex 2) on the calculation sheets, the sheets have to be copied before data checking(treated in chapter 5) takes place and the copies should be transferred to the re-use division's department head. In view of the anticipated future corrections to be applied, it is recommended to use a pencil for recording results on the calculation sheets (possibility of rubbing out erroneous data and/or results).

4.1. Discharge measurements processing

A distinction is made between the data processing of routine discharge measurements at open drains, at pump stations and calibration measurements.

4.1.1. Discharge data processing at open drains

Three types of data are collected at open drains. On a yearly basis the cross-sections at the measurement locations with access to the drains (bridges!) are determined and/or checked. With a fortnightly frequency float measurements and/or pendulum meter measurements are performed.

4.1.1.1. Cross-section measurements processing

During the cross-section measurements data are collected on the distances between the bridge surface and the drain bottom at regular intervals over the cross-section width both on the downstream and upstream side of the bridge (see annex 1). If the bridge surface is irregularly shaped level measurements are performed at the locations where these distances are measured. These measured distances d'(i) have to be corrected for the difference in elevation of the bridge surface on the corresponding location and the elevation of the bridge surface at the reference point(fig. 4-1)

$$d(i) = d'(i) + (R(i) - R_R) \qquad (4\text{-}1)$$

where:

d'(i) = distance from the bridge surface to the drain bottom at location i in m

R(i) = level instrument reading in m with the staff at location i on the bridge surface

R_R = level instrument reading in m with the staff at the reference point

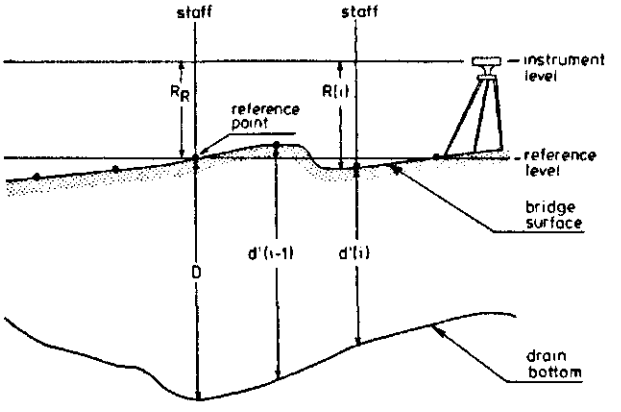


Fig. 4.1. Correction cross-section measurements for irregularity bridge surface

For the calculation of the float measurements the average of the cross-sections of upstream and downstream is required:

$$\bar{d}(i) = \{ d(i)_{upstr.} + d(i)_{downstr} \}/2 \qquad (4\text{-}2)$$

Per sub-section, in the centre of which in the rou-

tine programme the velocity will be measured, three depth measurements have normally been taken. Taking the occurence of piers into account the total area of the subsection can be calculated (see also fig. 4-2):

$$A_S = \bar{d}(i-1)\ \{\ell(i)/2 - p(i-1)\} + \bar{d}(i)\ \{\ell(i)/2 + \ell(i+1)/2 - p(i)\} + \bar{d}(i+1)\{\ell(i+1)/2 - p(i+1)\} \quad (4-3)$$

where:

A_S = total area subsection in m^2

$p(i)$ = thickness of the piers in the subsection in m

$p(i) = \sum_{k=1}^{n} p(i)_k$ (see fig. 4-2)

n = number of piers

$\ell(i)$ = distance between depth measurements in m

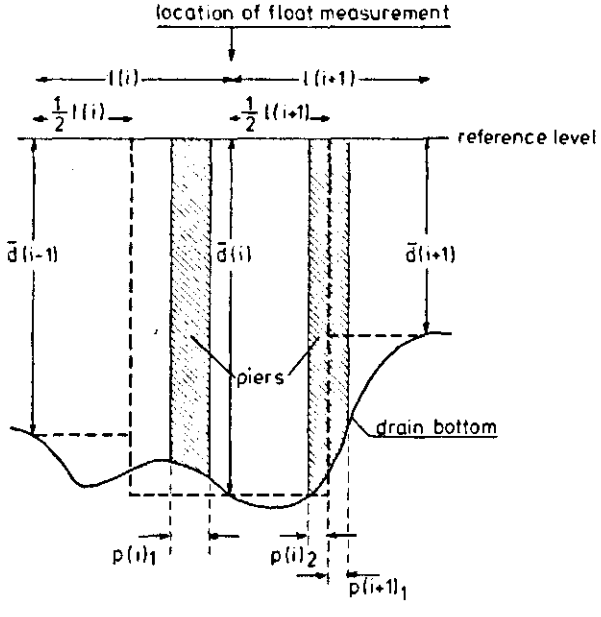


Fig. 4-2. Calculation total subsection area

The effective width of the subsection follows:

$$W = \ell(i) + \ell(i+1) - \{\ p(i-1) + (p(i) + (p(i+1))\} \quad (4-4)$$

where: W = effective (wet) width of the subsection in m

The complete procedure for the cross-section calculation is as follows (see example 4-1):

1. Calculate the upstream and downstream distances between reference level and drain bottom (eq.4-1). Record these distance on a calculation sheet (see example 4-1).
2. Prepare a graph on A 4 millimeter paper of the cross-section. Give on the left vertical axis the D-scale (see annex 2.4.1 fig. A 2-4 for the cross-section of example 4-1). Indicate location and thickness of the piers in this graph.
3. Calculate the total area of each sub-section, A_S, and the effective width, W. Record the results on the calculation sheet.
4. Prepare a table of the results (see annex 2) including:
   - date of observation
   - depth at reference point
   - bridge width
   - cross-section width
   - per subsection
     + effective section width
     + total area subsection.
5. Make a copy of the graph and table and transfer the copy to the department head. File the graph, table, field forms and calculation sheets.
6. Prepare a data card for the HP 97 programme 'Floats' This step will be discussed in chapter 4.1.1.2.
7. Yearly the depth at the reference point will be checked in the field. If deviations with the previous value are found a new cross-section measurement has to be performed.
8. The results of such a new measurement should be checked against the previous results. After preparing the graph, using the same scale (step 2), both graphs are placed on a light table. If no deviations are visible the previous measurements can still be considered reliable and steps 3-6 can be omitted.
9. If a difference is noticed steps 3-6 have to be performed, using the new measurements.
10. The effect of the change in cross-section can be evaluated by performing a discharge calculation using the old and the new data and comparing the results. If the difference between both is less than 5 %, future calculations can be continued with the new data card. If the difference is more than 5 % the discharges calculated in the past have to be corrected. If these is no reason to assume a sudden change in cross-section (bridge construction activities; reconstruction of drainage canals) this correction may be gradual decreasing with time until the last previous date on which the cross-section has been determined or checked.

Example 4-1. Calculation cross-section EB 07 (field data in annex 1.4.1)

Distance from zero-point (m)	depth d' (m)		$R-R_R$ (m)		Corrected depth d (m)		$\bar{d}$ (m)	Division sub-sections	p(i) (m)	W (m)	A_{S_2} (m^2)
	upstr	downstr	upstr	downstr	upstr	downstr					
0	1.80	1.54	-0.23	-0.01	1.57	1.53	1.55	0- 1			
2	2.64	2.26	-0.26	0.00	2.38	2.26	2.32	1- 3		4.00	8.96
4	3.08	2.71	-0.26	0.00	2.82	2.71	2.76	3- 4			
								4- 5			
6	3.39	3.22	-0.26	0.00	3.13	3.22	3.18	5- 7		4.00	12.88
8	3.96	3.85	-0.29	0.00	3.68	3.85	3.76	7- 8			
								8- 9			
10	3.85	3.34	-0.30	-0.01	3.55	3.33	3.44	9-11	0.60	3.40	12.23
12	3.98	3.63	-0.32	0.00	3.67	3.63	3.65	11-12			
								12-13			
14	4.15	3.82	-0.32	0.00	3.83	3.82	3.82	13-15		4.00	15.39
16	4.33	4.14	-0.32	0.01	4.01	4.16	4.08	15-16			
								16-17			
18	4.92	4.64	-0.32	-0.03	4.61	4.64	4.62	17-19		3.70	15.59
20	3.78	3.13	-0.33	-0.15	3.45	2.98	3.22	19-20	0.30		
								20-21	0.60		
22	3.85	3.90	-0.13	-0.12	3.72	3.78	3.75	21-23	0.20	3.10	11.74
24	4.79	3.95	-0.36	-0.15	4.43	3.80	4.12	23-24	0.10		
								24-25			
26	4.64	4.48	-0.32	-0.13	4.32	4.35	4.34	25-27		4.00	17.09
28	4.56	4.43	-0.29	-0.09	4.27	4.34	4.30	27-28			
								28-29			
30	4.70	4.56	-0.29	-0.07	4.41	4.49	4.45	29-31		3.90	17.07
32	4.74	4.23	-0.28	-0.11	4.47	4.12	4.32	31-32	0.10		
								32-33	0.50		
34	4.40	4.45	-0.08	-0.10	4.32	4.35	4.44	33-35	0.60	2.30	10.21
36	5.34	4.92	-0.30	0.00	5.04	4.92	4.98	35-36	0.60		
								36-37			
38	5.06	5.12	-0.26	0.00	4.80	5.12	4.96	37-39		4.00	19.79
40	4.98	5.08	-0.24	0.00	4.75	5.02	4.88	39-40			
								40-41			
42	5.00	4.93	-0.22	0.00	4.78	4.94	4.86	41-43		4.00	19.51
44	5.15	4.88	-0.22	-0.01	4.93	4.87	4.90	43-44			
								44-45	0.30		
46	4.68	4.54	-0.22	-0.01	4.47	4.53	4.50	45-47	0.30	3.40	14.94
48	3.83	4.08	-0.19	-0.01	3.64	4.07	3.86	47-48			
								48-49			
50	3.18	3.16	-0.21	0.00	2.97	3.16	3.06	49-51		4.00	12.46
52	2.64	2.52	-0.22	0.00	2.42	2.53	2.48	51-52			
								52-53			
54	2.14	1.67	-0.24	-0.02	1.91	1.66	1.78	53-54		2.00	4.26

- The depth d' is calculated as: No of pieces(m) - excess (cm), using the data of annex 1.4.1
- The correction for irregularity of the bridge surface is calculated as: instrument level reading R - reading at reference point R_R = 1.70, data of annex 1.4.1
- The corrected depth d (m) is calculated as the sum: $d' + (R-R_R)$
- The average depth $\bar{d}$ (m) is calculated as the average of upstream and downstream depth d
- The division sub-section gives the distances for which the measured depth is considered constant. In this column the subsections of 4 m are divided into ½ℓ (=1), ℓ (=2) and ½ℓ (=1) to facilitate the calculation of the total area of the subsection
- The width occupied by piers, p(i), is counted per 1 or 2 m, whichever one is pertinent from the field data in annex 1.4.1
- The effective sub-section width is calculated as the difference between sub-section width (2ℓ) and the width occupied by piers per subsection.
  For subsection 34 for example (section 32-36 m) : W = 4 -(0.50 + 0.60 + 0.60) = 2.30 m
- The total area of the subsection is calculated according to eq. 4-3.
  For subsection 34 for example: A_S = 4.32 (1-0.50) + 4.44 (2-0.60) + 4.98 (1-0.60) = 10.21 m^2

In equation (4-1) and in example (4-1) it has been assumed that on each location where the distance between bridge surface and drain bottom is measured a level measurement has been performed. If the bridge surface is smooth and straight, however, less level measurements have been performed and the level measurements for the intermediate points have to be interpolated (see also example 4-2):

$$R'(i) = R_A + i \frac{R_B - R_A}{n+1} \qquad (4\text{-}5)$$

where: R'(i) = interpolated value of the level measurements for point i in between the measured points A and B

Example 4-2. Interpolation level measurements EB 05 (field data in annex 1.3.1)

Distance (m)	Instrument level reading		Interpolated levels	
	upstream	downstream	upstream	downstream
0	1.603	1.628	1.60	1.63
0.5			1.59	1.62
1.0			1.57	1.61
1.5			1.56	1.60
2.0			1.54	1.59
2.5			1.53	1.58
3.0			1.52	1.57
3.5	1.502	1.560	1.50	1.56
4.0			1.50	1.55
4.5			1.49	1.54
5.0			1.48	1.52
5.5			1.48	1.51
6.0			1.47	1.50
6.5			1.46	1.49
6.9	1.457	1.478	1.46	1.48

Using the I register of the HP 97 the interpolation procedure proceeds as follows:

- Calcuate $R_B - R_A$: 1.502-1.603 = - 0.101
- Divide $R_B - R_A$ by n+1: -0.101 : 7 = - 0.014
- Store the quotient in the I register: STO I
- Enter R_A in the X register: 1.603 ENTER
- Add the contents of the I register to the X register: I + = 1.589 = R'(1)
  Round the result to two decimals and record the result: 1.59
- Repeat this step untill point B is reached (Distance 3.5m):

  I + = 1.574 R(2) = 1.57
  I + = 1.560 R(3) = 1.56
  I + = 1.545 R(4) = 1.54
  I + = 1.531 R(5) = 1.53
  I + = 1.516 R(6) = 1.52
  I + = 1.502 R_B = 1.50

R_A = level measurement at point A in m

R_B = level measurement at point B in m

n = number of intermediate measurements points between A and B

i = number of the intermediate measurement point; i = 1 at point A and i = n at point B

4.1.1.2. Float measurements processing

During the fortnightly routine measurement programme the waterlevel is measured at the reference point by measuring Hm, the distance between bridge surface and waterlevel in the drain. This distance Hm determines for each subsection recognized the part of the total area of the subsection above waterlevel:

$$A_d = Hm \; W \qquad (4\text{-}6)$$

where: A_d = area of the subsection above waterlevel in m^2

The wetted area of the subsection follows:

$$A_w = A_s - A_d \quad \text{for } A_s - A_d > 0$$
$$A_w = 0 \quad \text{for } A_s - A_d \leq 0 \qquad (4\text{-}7)$$

where: A_w = wetted area of the subsection in m^2

The surface velocity of the water in the drain can be calculated from the float traveling time per subsection:

$$v_s = B/t \qquad (4\text{-}8)$$

where: v_s = surface water velocity in $m\ s^{-1}$

B = width of the dridge in m

t = travel time of the float in s

For converting the surface velocity to the average velocity in the subsection the surface velocity may be multiplied with a factor. Although this factor may vary, a value of 0.85 is often found in practice:

$$\bar{v} = 0.85 \; v_s \qquad (4\text{-}9)$$

where $\bar{v}$ = average velocity in the subsection in $m\ s^{-1}$

The discharge in the i^{th} subsection can be calculated with:

$$Q(i) = A_w(i) \; \bar{v}(i) \qquad (4\text{-}10)$$

where Q(i) = fractional discharge through subsection i in $m^3.s^{-1}$

Sometimes floating waterplants accumulate on the upstream side of the bridge preventing the float measu-

rements to be implemented. Assuming that the waterplants prevent the waterflow for the top 0.5 meter of the subsection the fractional discharge can be approximated with:

$$Q(i) = \{A_w(i) - 0.5\, w(i)\} \frac{\bar{v}\,(i-1) + \bar{v}\,(i+1)}{2}$$

for $A_w(i) > 0.5\, W(i)$

$$Q(i) = 0 \quad \text{for } A_w(i) \leq 0.5\, W(i) \qquad (4\text{-}10a)$$

The average velocity in the cross-section calculated from the float measurements is:

$$\bar{v}_f = \sum_{i=1}^{n} Q(i)/A \qquad (4\text{-}11)$$

where: $\bar{v}_f$ = average velocity in the cross-section in $m\ s^{-1}$

n = number of subsection in the cross-section

$A = \sum_{i=1}^{n} A_w(i)$ = wetted cross-section in m^2

If some calibration measurements have been performed in the past the average flow velocity $\bar{v}_f$ may be multiplied with the correction factor (treated in chapter 5):

$$c'_D = a + b\ D \qquad (4\text{-}12)$$

where: c'_D = correction factor

a,b = empirical constants

D = waterdepth at reference point in m

The (corrected) discharge can then be calculated:

$$Q_f = A\ \bar{v}_f\ c'_D \qquad (4\text{-}13)$$

where: Q_f = discharge in $m^3 s^{-1}$, calculated from the float measurements

If sufficient calibration measurements have been performed in the past and a sufficiently reliable stage-discharge relation has been established, the float measurements will no longer be used for the calculation of discharge. The Hm measurements will then be directly related to discharge. This matter will be treated in chapter 4.2.2.

The equations (4-6) - (4-11) have been programmed for the HP 97 calculator. The programme 'Floats' operates in combination with a data card on which the results of the cross-section measurements are compiled.

The following sub-programmes (key board controlled) are distinguished (see annex 8.1 for the programme listing and user instructions):

LBL a. In this sub-programme a flag (signal) is set to indicate the occurrence of waterplants in the sub-section.

LBL b. In this sub-programme Hm is read and stored and the calculator is initialized.

LBL A. This is the main programme. The travel time, t, is read and the fractional discharge calculated and stored (see flow diagramme fig. 4-3).

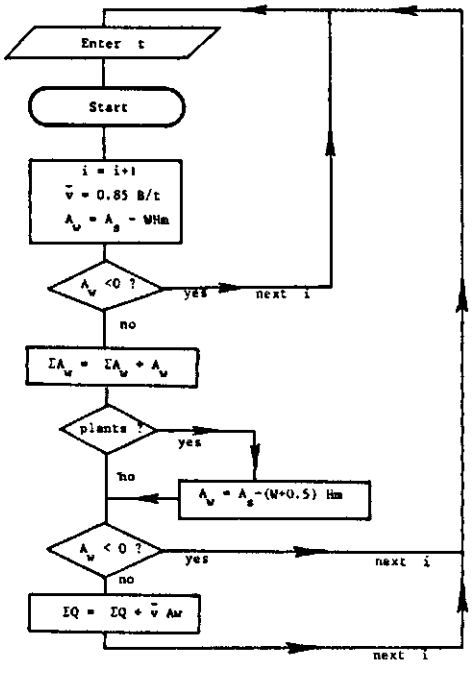


Fig. 4-3. Flow diagramme of the main programme (LBL A) of the HP 97 programme 'Floats'

LBL B. In this sub programme the average velocity is calculated and the results are printed: waterdepth, D, wetted cross-section, A, discharge for $c'_D = 1$, Q, and average velocity, $\bar{v}_f$.

The complete procedure for the float measurement calculations is as follows:

1. Prepare a data card for the result of the cross-section measurements (once after every new cross-section measurement). See also example (4-3).
   - prepare a list with cross-section data in reversed order (last subsection first) with the effective subsection width, w, in cm before the decimal point and the total area, A_s, in dm^2 behind the decimal point, using 4 digits for A_s (see example 4-3);
   - store these data one by one in the calculator's register, starting with register 9, 8, ..., 0;
   - if less than 10 sebsections have been recognized protect the data after all subsections have been entered by pressing the keys f and P ⇄ S;
   - if more than 10 subsections have been recognized protect the data of the first 10 subsections after they have been entered by pressing the keys f and P ⇄ S and continue storing the

Example 4-3. Preparation data card for the HP 97 programme 'Floats' for EB 07 (cross-section data in example (4-1) and in annex 2.4.1)

Input	Keys	Display	Comments
200.0426	STO 9		$W.A_s$ subsection 53
400.1246	STO 8		" 50
340.1494	STO 7		" 46
400.1951	STO 6		" 42
400.1979	STO 5		" 38
230.1021	STO 4		" 34
390.1707	STO 3		" 30
400.1709	STO 2		" 26
310.1174	STO 1		" 22
370.1559	STO 0		" 18
	f P ←→S		protect data of first 10 subsections
400.1539	STO 9		$W.A_s$ subsection 14
340.1223	STO 8		" 10
400.1288	STO 7		" 6
400.0896	STO 6		" 2
5	STO I		n
5.02	STO C		D + Hm (total depth at reference point)
4.05	STO B		B
	f WDATA	crd	Prepare calculator for writing data on card
		crd	Enter empty card side 1
			Enter "-" side 2

remaining data starting again with register 9, 8, ... 3*;

- determine the initial counter value n:

  n = 19 - number of subsections recognized

  and store n in register I;
- store D + Hm in register C and B in register B
- prepare the calculator for writing data on card by pressing the keys f and WRITE DATA;
- enter an empty (clean) card side 1 and side 2;
- write with pencil on the card (taking care not to press the pencil too hard to avoid damage) the measurement point identification number, its name, and the value of n.

2. Calculate waterdepth, wetted cross-section and average 'float' velocity with the programme 'Floats' following the user instructions given in annex 8.1 (see also Example 4-4).
3. Prepare the heading of the calculation sheet (see annex 2).
   Record the observation year, catchment area (name of the drain at the outlet to the sea), the measurement point identification code, the waterdepth - Hm relation, the pendulum constant (if applicable) found from the observations of the previous year, the float constant (if applicable) found from observations of the previous year, and the calibration relation (if applicable) found with sufficient accuracy from the calibration measurements performed.

* Register 3 is the first register reserved for the 'bridge data' (see annex 8.1)

4. Record the calculated waterdepth, wetted cross-section and average velocity on the calculation sheets (see annex 2). The format for waterdepth is 2 digits behind the decimal point (D.DD), for the cross-section 2 digits behind the decimal point (AAA.AA), and for the velocity 3 digits behind the decimal point (V.VVV).
5. For the calculation of discharges two possibilities do exist. Based on the calculations of the previous observation year it has been decided whether the float measurements or the pendulum measurements have to be used for the calculation of discharge. This choice of method to be used will be treated in chapter 5.2.

   - If the pendulum meter measurements have been identified as the more reliable method, and if pendulum measurements have been performed on the measurement date for which the calculations are being carried out, the average 'float' velocity will only be used as a check on the pendulum measurements;
   - If the float measurements have been identified as the more reliable method, or if pendulum measurements have not been performed for the measurement date for which the calculations are being carried out, or if pendulum measurements have not been considered for the measurement point in question, the discharge can be calculated with (eq. 4-13) as the product of $\bar{v}_f$, A and the depth-dependable correction factor c'_D, that has been determined empirically by com-

Example 4-4. Calculation average 'float' velocity (field data from annex 1.2.2)

Input	Keys	Output	Comments
			enter programme card 'Floats'
			enter data card FB 04, Roda drain; n = 12
3.85	f B		Hm (measuring date 9/01/'80)
14.4	A		t, subsection 0.5
7.6	A		t, subsection 1.5
7.6	A		t, subsection 2.5
	f A		plants in subsection 3.5
7.1	A		½ (t subsection 2.5 + t subsection 4.5)
6.6	A		t, subsection 4.5
5.7	A		t, subsection 5.5
5.7	A		t, subsection 6.5
	B	0.55	D
		3.35	A
		2.90	Q
		0.865	v_f
12	STO I		reset counter for next calculation
4.39	f B		Hm (measuring date 23/01/'80)
	EEX 9		water not flowing in subsection 0.5
	A		
	EEX 9		water not flowing in subsection 1.5
	A		
10.8	A		t, subsection 2.5
	f A		plants in subsection 3.5
13.9	A		½ (t subsection 2.5 + t subsection 5.5)
	f A		plants in subsection 3.5
13.9	A		½ (t subsection 2.5 + t subsection 5.5)
17	A		t, subsection 5.5
21.8	A		t, subsection 6.5
	B	0,01	D
		0.45	A
		0.12	Q
		0.264	v_f

paring the routine measurements of the previous observation year with the calibration measurements.

Because 1980 has been the first year of observation no example can be given here of the correction factor c'_D. In chapter 5 it will be shown how this coefficient can be derived and in the calculations given in annex 2 c'_D has been assumed unity (= 1).

6. Record the calculated discharge with 2 digits behind the decimal point (QQQ.QQ) on the calculation sheet (if applicable).
7. Check the discharge against the waterdepth with the relation between both, established with the data of the previous observation year. No examples can be given here, because 1980 is the first year of observation. In fig. (4-4) the general shape of such a relation is given. If the calculated data pair (D, Q) is found outside the area enclosed by the upper and lower enveloping curves, the field data and the subsequent calculations have to be checked on possible mistakes.

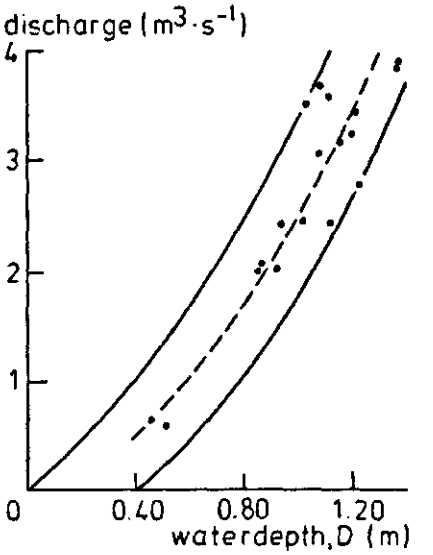


Fig. 4-4. Example of stage-discharge relation with enveloping curves based on routine measurements

The steps 1 and 3 of this precedure do not need to be repeated for each measurement. Step 1 is performed for every new cross-section measurement and step

3 for each new observation year.

4.1.1.3. Pendulum meter measurements processing

The principle of the velocity measurements with he hand pendulum meter is to lower a resistance body into the flowing water, suspended by a cable from the bridge railing, and measuring both the length of the cable below the water surface and the angle between the cable above the water surface and the vertical. This angle is caused by the flowing water pushing against both the resistance body and the cable below the water surface (fig. 4-5).

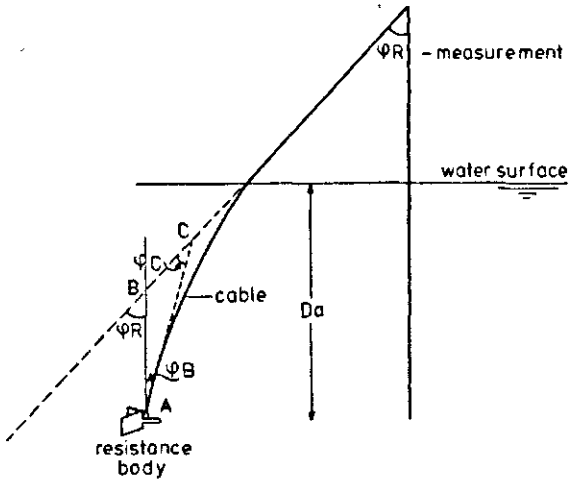


Fig. 4-5. Relation between pendulum reading ϕ_R, resistance body angle, ϕ_B, and cable inclination, ϕ_C

The local velocity in point A is related to the angle between the cable at point A and the vertical A-B. The depth at which the measurement is taken, Da, is related to the cable length suspended below the watersurface, the measured angle, ϕ_R, and the inclination of the cable below the water surface due to the velocity distribution from water surface to point A.

Considering the triangle ABC in fig. 4-5 where AB is the vertical, BC is the extrapolation of the cable above the water surface and AC is the tangent to the cable at point A, the following relation is found:

$$\phi_R = \phi_B + \phi_C \qquad (4\text{-}14)$$

where: ϕ_R = angle reading at the pendulum instrument in degrees

ϕ_B = resistance body inclination at point A in degrees

ϕ_C = cable inclination in degrees

The velocity in point A is related to ϕ_B:

$$v^2 = K_2 \operatorname{tg} \phi_B \qquad (4\text{-}15)$$

where: v = velocity in point A in $m.s^{-1}$

K_2 = constant, depending on the resistance body type used, in $m^2.s^{-2}$

The constant K_2 is defined as:

$$K_2 = \frac{2(P_b - P_w)\, V g}{P_w\, C_{Db}\, A} \qquad (4\text{-}16)$$

where: P_b = density resistance body in $kg.m^{-3}$

P_w = density of water in $kg.m^{-3}$

V = volume resistance body in m^3

g = acceleration of gravity in $m.s^{-2}$

C_{Db} = drag coefficient resistance body

A = area in m^2 of the resistance body in the direction of water flow

Taking P_w = 1000 and g = 9.81 the manufacturer gives the following values for K_2:

Resistance body type	K	L	M	N
K_2	0.666	1.825	3.64	6.30

In order to reduce the measured angle ϕ_R to the resistance body angle ϕ_B the cable inclination ϕ_C has to be calculated for each measurement n:

$$\phi_C = K_1 \cos^3 (\phi_R - \phi_C/2) \sum_{n=1}^{m} v^2_{n-1}\, \Delta Ln \qquad (4\text{-}17)$$

where: K_1 = constant depending on the resistance body type

ΔLn = increase in cable length in m between observation n and observation n-1

The constant K_1 is defined as:

$$K_1 = \frac{360}{4\pi} \frac{P_w C_{Dc}\, D}{(P_b - P_w) Vg} \qquad (4\text{-}18)$$

where: C_{Dc} = drag coefficient of the cable in m

D = diameter of the cable in m

Taking P_w = 1000, C_{Dc} = 0.9838, D = 0.75 x 10^{-3} and g = 9.81 the manufacturer gives the following values for K_1:

Resistance body type	K	L	M	N
K_1	3.315	3.650	0.860	0.855

Equation (4-17) cannot easily be solved. The angle ϕ_C can be approximated with the equation:

$$\phi_C = K_1 \sum_{n=1}^{m} v_{n-1}^2 \Delta Ln \qquad (4\text{-}19)$$

Substitution of this expression for ϕ_C in the right hand side of equation (4-17) gives:

$$\phi_C = K_1 \cos^3\left(\phi_R - \frac{K_1 \sum_{n-1}^{m} v_{n-1}^2 \Delta Ln}{2}\right) \sum_{n=1}^{m} v_{n-1}^2 \Delta Ln \qquad (4\text{-}20)$$

The depth at which measurement m has been taken can be calculated with:

$$D_a = \cos\left(\phi_R - \frac{\phi_C}{2}\right) \sum_{n=1}^{m} \Delta Ln + H/2 \qquad (4\text{-}21)$$

where: Da = depth of measurement in m

H = vertical dimension of the resistance body in m (0.14 for type K and 0.12 for types L, M and N)

Substitution of equation (4-19) gives:

$$D_a = \cos\{\phi_R - (K_1/2) \sum_{n=1}^{m} v_{n-1}^2 \Delta Ln\} \sum_{n-1}^{m} \Delta Ln + H/2 \qquad (4\text{-}22)$$

Both equations (4-21) and (4-22) are based on the assumption that the first reading of the pendulum meter is taken with the resistance body just submerged ($\Delta L_1 = 0$; $\phi_C = 0$). giving $D_a = H/2$ for the first measurement.

On the condition that sufficient measurements in the vertical section have been performed, the average velocity can be approximated by the weighted arithmetic mean velocity using the depth intervals as weights:

$$\bar{v}_p = \frac{1}{2D}\left[\{H + D_a(2) - D_a(1)\}\, v(1) + \sum_{n=2}^{m=1} \{D_a(n+1) - D_a(n-1)\}\, v(n) + \{D - D_a(m-1)\}\, v_m\right] \qquad (4\text{-}23)$$

with: $\bar{v}_p$ = average velocity in the vertical in $m.s^{-1}$

n = 1,2,3,.....,m, number of the individual measurements, n-1 for the surface measurement and n=m for the last measurement near the drain bottom

If not sufficient measurements have been performed, equation (4-23) becomes inaccurate, and a different approach gives better results.

The vertical velocity distribution in open channels can be approximated by assuming a logarithmic function of depth:

$$v = a + b \ln y \qquad (4\text{-}24)$$

where: a and b are constants

$y = D - D_a$, waterdepth in m

The constants a and b in equation (4-24) are not independent. This can be illustrated by considering y = 0:

$$\lim_{y \to 0} \ln y = -\infty \qquad (4\text{-}25)$$

Equation (4-24) is therefore not valid for the complete range of depth values. Assuming v = 0 for $y = y_o$ gives for the relation between a and b (subsitution in 4-24):

$$a = -b \ln y_o \qquad (4\text{-}26)$$

and equation (4-24) reduces to:

$$v = b \ln (y/y_o) \qquad (4\text{-}27)$$

Taking $b = 2.5 (\tau_o/P)^{\frac{1}{2}}$ where τ_o is the shearforce in $kg\ m^{-2}$ and P is the density of water in $kg\ m^{-3}$ in equation (4-27) the logarithmic velocity distribution known in the literature (VEN TE CHOW, 1959, p.201) is found.

Using linear regression analysis techniques a and b can be determined from a limited number (but more than 2) of depth and velocity observations:

$$b = \frac{\sum_{n=1}^{m} v_n \ln y_n - \frac{1}{m} \sum_{n=1}^{m} \ln y_n \sum_{n=1}^{m} v_n}{\sum_{n=1}^{m} (\ln y_n)^2 - \frac{1}{m} \left(\sum_{n=1}^{m} \ln y_n\right)^2} \qquad (4\text{-}28a)$$

$$a = \frac{1}{m}\left(\sum_{n=1}^{m} v_n - b \sum_{n=1}^{m} \ln y_n\right) \qquad (4\text{-}28b)$$

The average velocity can be found by integration of equation (4-27):

$$\bar{v}_p = b/D \int_{y_o}^{D} \ln(y/y_o)\, dy = b\,\{\ln(D/y_o) - 1 + y_o/D\} \qquad (4\text{-}29)$$

The constant y_o can be expressed as a function of the constants a and b and can be found by reformulation of equation (4-26):

$$y_o = e^{-a/b} \qquad (4\text{-}30)$$

Substitution in equation (4-29) gives:

$$\bar{v}_p = a + b\,(\ln D - 1 + D^{-1} e^{-a/b}) \qquad (4\text{-}31)$$

Equation (4-31) does not always provide the proper average velocity value. Specifically this may be the case when the velocity distribution is rather straight and due to the meaurement inaccuracies the curve fitting procedure gives a positive value for a and a negative value for b. An inverse velocity distribution is then found and the average velocity calculated with equation (4-31) becomes negative*.

* The calculated result becomes negative because the y_o value calculated with equation (4-30) becomes greater than D. As a consequence the integration boundaries in equation (4-29) have to be changed

In this case a better approximation of the average velocity is found by taking the arithmetic average:

$$\bar{v}_p = \frac{1}{m} \sum_{n=1}^{m} v_n \qquad (4\text{-}32)$$

The average velocity in the vertical at the reference point, $\bar{v}_p$, is related with the average velocity in the cross-section, calculated from the float measurements, $\bar{v}_f$. A linear relationship between both has been assumed:

$$\bar{v}_f = c_p \bar{v}_p \qquad (4\text{-}33)$$

where c_p = constant

If some calibrations have been performed in the past, the correction factor c'_D (equation 4-12) is validated and the equation for the (corrected) discharge calculated from the pendulum meter measurements becomes:

$$Q_p = A \bar{v}_p c_p c'_D \qquad (4\text{-}34)$$

where Q_p = discharge in $m^3.s^{-1}$, calculated by the pendulum method.

The velocity distribution presented in fig. 4-6 a will be used to illustrate the different approaches to the calculation of the average velocity.

Weighted average. Provided that sufficient measurements have been made (Da/D > 0.8) the weighted average (equation 4-23) should be calculated. In fig. 4-6 a this methode is illustrated for a complete measurement (n = 15), where over the complete depth range (3 m) velocity observations have been made. The calculated average velocity ($\bar{v}_p$ = 0.319) can be considered as the best estimate of the true average velocity. In fig. 4-6 b the same method (equation 4-23) using the same measurements but excluding the lowest two (n = 13) is illustrated. The condition Da/D > 0.8 is fulfilled. Comparison with fig. 4-6 a clearifies the difference between both. For the incomplete measurement a lower calculated average velocity results ($\bar{v}_p$ = 0.304).

Regression analysis. If insufficient measurements have been taken (Da/D < 0.8) the regression analysis (equation 4-31) should be used. In fig. 4-6 c this method is illustrated using the data of fig. 4-6 a, omitting the last 4 velocity measurements (n = 11). The least square logarithmic velocity distribution is given and the average velocity calculated ($\bar{v}_p$ = 0.328).

Arithmetic average. If the regression analysis method gives negative results the velocity profile is reversed (highest velocity near the bottom) and the arithmetic average (equation 4-32) should be calculated.

In fig. 4-6 d this method is illustrated by using the first 6 measurements (n = 6) of fig. 4-6 a. In the figure 4-6 d the reversed velocity profile (least square line) is indicated and the calculated average velocity (equation 4-32) given ($\bar{v}_p$ = 0.351).
The results of these 4 cases recognized are summarized in table 4-1, together with the fractional deviation from the best estimate for the true average (weighted average for the complete measurement, n=15).

Calculation method	Number of observations			
	n=15	n=13	n=11	n=6
Weighted average (4-23)	0.319 (0.00)	0.304(0.05)	0.328(0.29)	0.148(0.54)
Regression analysis(4-31)			0.328(0.03)	- 122.981
Arithmetic average (4-32)				0.351(0.10)

Table 4-1. Average velocity, $\bar{v}_p$, calculated for different number of observations. The numbers between brackets give the fractional deviation compared with, n=15, equation (4-23), $\bar{v}_p$ = 0.319

Although for other sets of measurements different results may be obtainted, the data in table 4-1 give an indication of the reliability of the average velocity calculated with the methods proposed (maximum deviation in the order of magnitude of 10%).

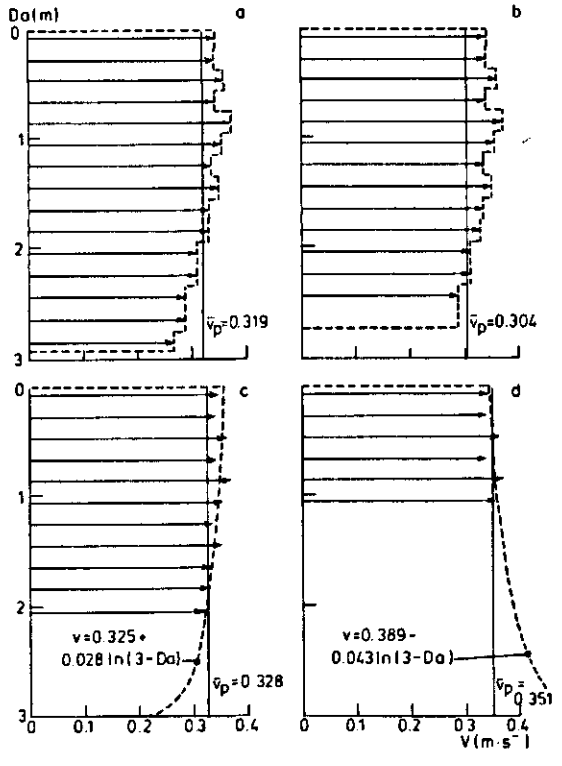


fig.4-6.Calculation average velocity in a vertical
a. Complete measurement,n=15,weighted average (eq. 4-23)
b. Incomplete measurement,$Da_m > 0.8D$, n=13, weighted average (eq.4-23)
c. Incomplete measurement, $Da_m < 0.8D$,n=11 regression analysis (eq.4-31)
d. Incomplete measurement, $Da_n < 0.8D$,n=6,reversed velocity profile,arithmetic average (eq.4-32)

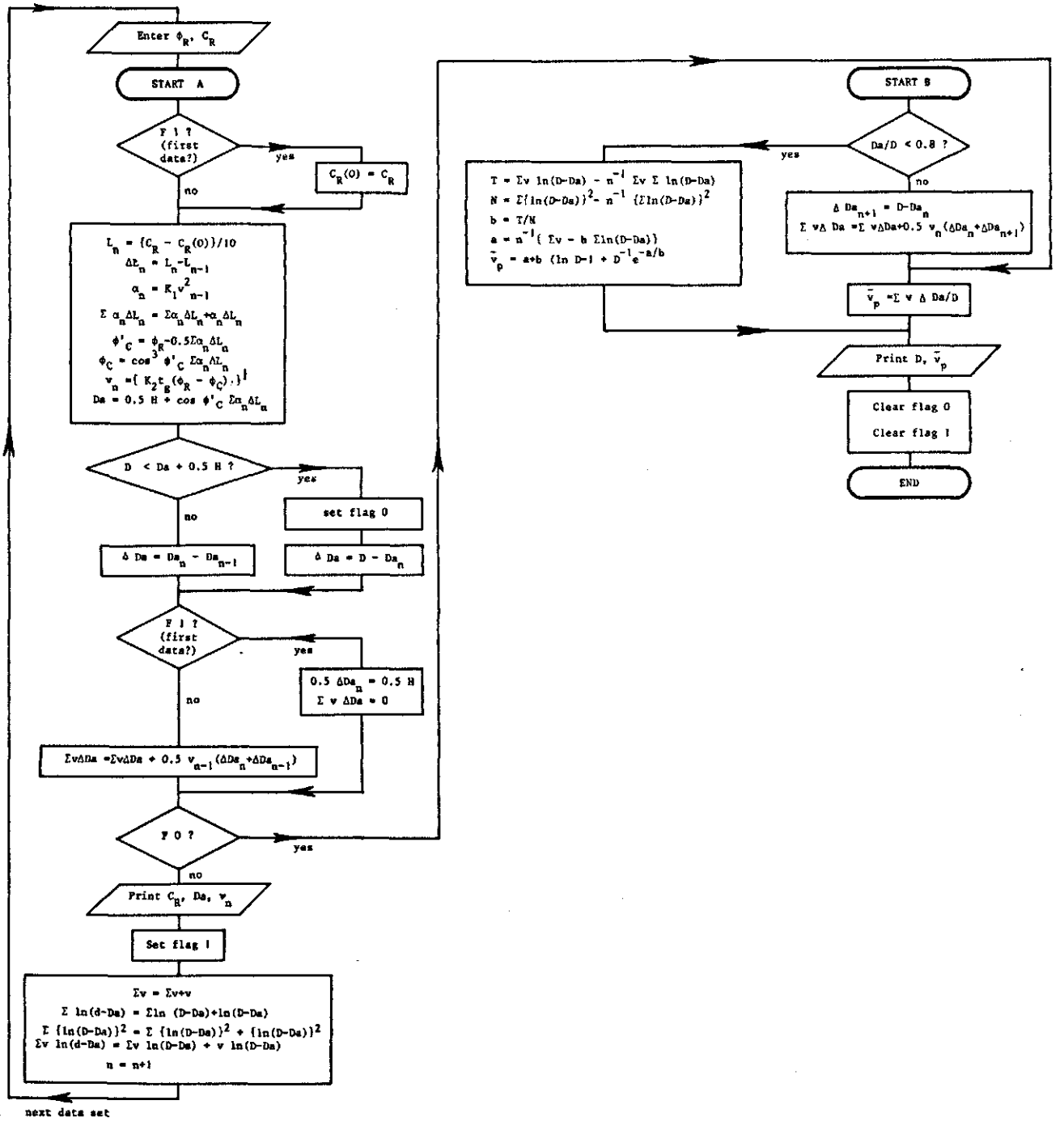


Fig. 4-7. Flow diagramme main programme (LBL A) and sub programme (LBL B) of the HP 97 programme 'Hand pendulum meter'

The equations (4-14),(4-15),(4-20),4-22),(4-23), (4-28) and (4-31) have been programmed for the HP 97 calculator. Unfortunately the memory space available (224 programme steps) is not sufficient to include equation (4-32). The programme 'Hand pendulum meter' operates in combination with a data card on which the characteristics of the resistance bodies are compiled. The organization of the data card is as follows:

Register	Resistance body	Identification	H	K_1	K_2
S_0	K	7.3315 0666	0.14	3.315	0.666
S_1	L	6.3650 1825	0.12	3.650	1.825
S_2	M	6.0860 3640	0.12	0.860	3.640
S_3	N	6.0855 6300	0.12	0.855	6.300

The number before the decimal point gives 0.5 H in cm, the first 4 digits behind the decimal point are reserved for K_1 and the last 4 digits for K_2.

The following (key-board controlled) sub programmes are distinguished (see annex 8.2 for the programme listing and user instructions):

LBL a. In this sub programme the waterdepth at reference point D is read and stored. A code number i for the resistance body type is read (i = 1 for body K, 2 for L, 3 for M and 4 for N) and the resistance body identification number is split into the constants H, K_1 and K_2 and stored. The registers that will be used for sums in the programme are cleared (programme initialisation).

LBL A. This is the main programme. The measured angle ϕ_R and the depth counter reading C_R in dm are read, the actual depth of observation Da and velocity v_n are calculated and stored. The depth counter reading C_R, depth Da and velocity v_n are printed. If the programme calculates a depth of observation Da that is greater than the waterdepth at reference point D this programme (LBL A) transfers execution to sub programme LBL B for the calculation of the average velocity $\bar{v}_p$. Therefore the flow diagrammes of both the main programme LBL A and the sub programme LBL B are combined in fig. 4-7.

LBL B. In this sub programme the average velocity $\bar{v}_p$ is calculated and D and $\bar{v}_p$ are printed. If under LBL A the calculated depth Da is found greater than D, LBL B is not key board controlled, but (part of) the sub programme is automatically excecuted by the main programme (see flow diagramme in fig. 4-7).

The complete procedure for the pendulum meter calculations is as follows:

1. Calculate the average velocity $\bar{v}_p$ with the programme 'Hand pendulum meter' following the user instructions given in annex 8.2 (see also example 4-5).
2. Record the calculated average velocity with 3 digits behind the decimal point (v.vvv) on the calculation sheet (annex 2).
3. Check the average pendulum velocity against the average float velocity with the relation between both established with the data of the previous observation year. No examples can be given here because 1980 is the first year of observation. In fig. 4-8 the general shape of such a relation is given.

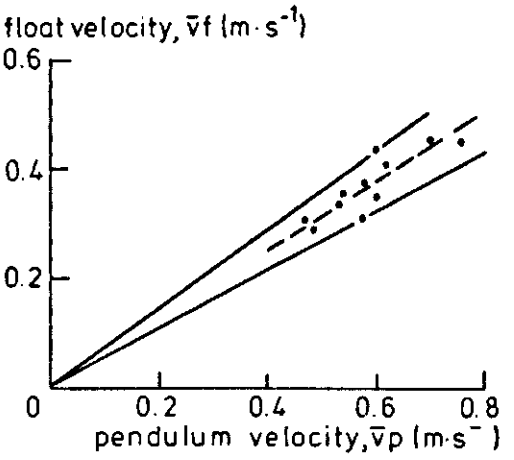


Fig. 4-8. Example of 'float' velocity-'pendulum' velocity relation with enveloping curves based on routine measurements

If the calculated data pair ($\bar{v}_f$, $\bar{v}_p$) is found outside the area enclosed by the upper and lower enveloping curves the field data of both the floats and hand pendulum meter measurements and the sub sequent calculation have to be checked on possible mistakes.

4. For the calculation of discharge two possibilities do exist (see also chapter 4.1.1.2). Based on the calculations of the previous observation year it has been decided whether the float measurements or the pendulum meter measurements have to be used for the calculation of discharge. This choice of method to be used will be treated in chapter 5.2.
   - If the float measurements have been identified as the more reliable method, the calculated average pendulum meter velocity will be used as a check on the float measurements (step 3) and the steps 4-6 can be deleted.
   - If the pendulum meter measurements have been identified as the more reliable method, or if

Example 4-5. Calculation average 'pendulum' velocity (field data from annex 1.1.3)

Input	Keys	Output	Comments
			Enter card with programme 'Hand pendulum meter'
			Enter card with data
1.12	ENTER ↑		Water depth FB 03 dd. 09/11/80
1	f A		Resistance body type K
20.5	ENTER ↑		Input ϕ_R
39	A	39.	Input C_R and output C_R
		0.07	Output depth of measurement Da
		0.50	Output actual velocity v_1
19.5	ENTER ↑		Input ϕ_R
40	A	40.	Input C_R and output C_R
		0.16	Da
		0.48	v_2
21.5	ENTER ↑		ϕ_R
42	A	42.	C_R (input and output)
		0.35	Da
		0.51	v_3
23	ENTER ↑		ϕ_R
44	A	44.	C_R (input and output)
		0.53	Da
		0,53	v_4
22.5	ENTER ↑		ϕ_R
46	A	46.	C_R (input and output)
		0.72	Da
		0.52	v_5
19.5	ENTER ↑		ϕ_R
48	A	48.	C_R (input and output)
		0.92	Da
		0.48	v_6
22.5	ENTER ↑		ϕ_R
49	A	49.	C_R (input and output)
		1.00	Da
		0.52	v_p
	B	1.12	$\underline{D}$ = water depth at reference point
		0.475	$\underline{v}_p$ = average pendulum velocity
1.08	ENTER ↑		water depth at reference point FB 03 dd 18/04/80
3	f A		resistance body type M
6.5	ENTER ↑		ϕ_R
3.6	A	36.	C_R (input and output)
		0.06	Da
		0.64	v_1
18	ENTER ↑		ϕ_R
38	A	38.	CR
		0.26	Da
		0.71	v_2
8.5	ENTER ↑		ϕ_R
40	A	40.	C_R (input and output)
		0.46	Da
		0.73	v_3
8	ENTER ↑		ϕ_R
42	A	42.	C_R (input and output)
		0.65	Da
		0.70	v_4
7.5	ENTER ↑		ϕ_R
44	A	44.	C_R (input and output)
		0.85	Da
		0.68	v_5
7.5	ENTER ↑		ϕ_R
46	A	46.	$\underline{C}_R$ (input and output)
		0.622	v_p, average pendulum velocity. The resistance body reaches the drain bottom during this measurement
1.11	ENTER ↑		waterdepth FB 03 dd. 30/04/80
2	f A		resistance body type L
12.5	ENTER ↑		ϕ_R
37	A	37.	C_R (input and output)
		0.06	Da
		0.64	v_1
16	ENTER ↑		ϕ_R
38	A	38.	C_R (input and output)
		0.16	Da
		0.72	v_2
16	ENTER ↑		ϕ_R
39	A	39.	C_R (input and output)
		0.25	Da
		0.72	v_3
15.6	ENTER ↑		ϕ_R
40	A	40.	C_R (input and output)
		0.35	Da
		0.70	v_4
16.5	ENTER ↑		ϕ_R
42	A	42.	C_R (input and output)
		0.54	Da
		0.72	v_5
	B	1.11	Calculate results D = 1.11
		- 324.175	$\underline{v}_p$, average pendulum velocity negative. Velocity distribution reversed.
	f P ↛ S		Expose the protected registers S 0 - S 9
	RCL 9		Σv_n = 3.49
	I		$\underline{n}$ = 5
	÷		$\underline{v}_p$ = 0.70
	f P ↛ S		Expose the non-protected registers 0 - 9
	DSP 3	0.698	Give $\underline{v}_p$ with 3 decimals

float measurements have not been performed on the date for which the calculations are beinig carried out, or if float measurements have not been considered for the measurement point in question, the discharge can be calculated (eq. 4-34) as the product of $\bar{v}_p$, A, c_p and c'_D. The correction factor c_p has been determined empirically by comparing the float and pendulum measurements of the previous observation year and the depth-dependable correction factor c'_D by comparing the routine measurement (Q_f or Q_p) of the previous observation year with the calibration measurements.

Because 1980 has been the first year of observation no example van be given here of the correction factors c_p and c'_D, and in annex 2 no discharges have been calculated using the pendulum meter measurements. In chapter 5 it will be shown how these coefficients can be derived.

5. Record the calculated discharge with 2 digits behind the decimal point (QQQ.QQ) on the calculation sheet (if applicable
6. Check the discharge Q_p against the water depth with the relation between both established with the data of the previous observation year. No examples can be given here because 1980 is the first year of observation. In chapter 4.1.1.2, figure 4-4 an example of such a relation has been given. If the calculated data pair (D, Q) is found outside the area enclosed by the upper and lower enveloping curves, the dield data and the subsequent calculations have to be checked on possible mistakes.

4.1.2. Discharge data processing at pump stations

The discharge data processing at pump stations has been the responsibility of the Ministry of Irrigation ever since this ministry started constructing pump stations. Depending on the availability of capacity curves for the pump units the daily volume of water pumped is calculated.

$$V = 3600\ N\ Q_F \qquad (4\text{-}35a)$$

if this curve is not available, or

$$V = 3600\ N\ Q_H \qquad (4\text{-}35b)$$

if such a capacity curve is used,

where: V = daily volume of water pumped in m^3
N = number of pumping hours
Q_F = capacity of the pump unit in $m^3.s^{-1}$ (fixed)
Q_H = idem (in relation to ΔH, the suction head in m)

The results communicated by the Ministry of Irrigation to other users (such as DRI) are the total volumes of drainage water pumped per month or per decade (see annex 1). For the conversion of these total volumes to discharges the following relation can be used:

$$Q = \frac{V'}{86400\ n} \qquad (4\text{-}36)$$

where: V' = total volume pumped per month or decade in m^3
n = number of days in the month or decade* considered

If calibration measurements have been performed the relation between discharge and suction head is known (see annex 2.6.1):

$$Q' = Q_o + S\Delta H \qquad (4\text{-}37)$$

where: Q_o = Q' axis intercept for $\Delta H = 0$ in $m^3.s$
S = slope of the relation ($= dQ/d(\Delta H)$)

On the condition that data on the average suction head during the calculation period considered can be obtained the discharges calculated with equation (4-36) can be corrected for the actual suction head:

$$Q_c = Q\ \frac{Q'(\overline{\Delta H})}{Q_F} \qquad (4\text{-}38a)$$

if no capacity curve has been used, and

$$Q_c = Q\ \frac{Q'\ (\overline{\Delta H})}{Q_H\ (\overline{\Delta H})} \qquad (4\text{-}38b)$$

if such a curve has been used for the calculation of V,

where: Q_c = average discharge in $m^3.s^{-1}$ corrected for average suction head
$Q'(\overline{\Delta H})$ = discharge at suction head $\overline{\Delta H}$ according to the calibration measurements
$\overline{\Delta H}$ = average suction head in m during the period considered
$Q_H(\overline{\Delta H})$ = discharge at suction head $\overline{\Delta H}$ according to the capacity curve used by the Ministry of Irrigation

The complete calculation procedure is as follows:

1. Calculate the average discharge during the period considered (month, decade) according to equation (4-36).
2. Correct the discharge calculated for the actual average suction head during the period considered (equation 4-38). If no calibration measurements have been performed at the pump station in question step 2 can be omitted. If calibrations have been performed the following additional information must be collected from the Ministry of Irrigation:
   + the method according to which the reported volumes of drainage water have been calculated

* Normally a decade has 10 days (n=10). The decade Feb.III, however, may have 8 or 9 days, and the decades Jan.III, Mar.III, May III, Jul.III, Aug.III, Oct.III and Dec.III have 11 days (n=11)

(capacity curve or fixed capacity);

+ the average suction head $\overline{\Delta H}$ during the periods considered;
+ the details of the capacity curve used or the exact fixed capacity used for the calculation of the reported volumes.

After obtaining this information the corrected discharges are calculated in the following way:

- calculate Q_H $(\overline{\Delta H})$ using the capacity curve of the Ministry of Irrigation (if applicable);
- calculate $Q'(\overline{\Delta H})$ using the calibration relation (4-37);
- calculate the corrected discharge Q_c using equation (4-38).

3. Record the calculated discharges on the calculation sheet with 2 digits behind the decimal point (QQQ.QQ). Record the average suction head during each period with 2 digits behind the decimal point (H.HH). Report this for every date on which water quality measurements have been performed, but at least once during every period (month, decade)considered.See annexes 2.9 and 2.10 for examples of a monthly period and annexes 2.11 and 2.12 for examples of decades.

Of the 4 pump stations for wich routine measurement data have been collected (annex 1.9 - 1.12) no calibration measurements have been performed. As a consequence the results presented in annexes 2.9 - 2.12 have been calculated with equation (4-36) and no examples of the correction for actual suction head procedure can be given here.

4.2. Water quality measurements processing

The laboratory analysis results (EC, $[Ca^{2+}]$, $[Mg^{2+}]$, $[Na^{+}]$, $[K^{+}]$, $[CO_3^{2-}]$, $[HCO_3^{-}]$, $[SO_4^{2-}]$ and $[Cl^{-}]$)* can be used to calculate certain water quality parameters, such as the SAR , sodium adsorption ratio, adj. SAR and RSC (residual sodium carbonate). The calculation of these parameters is facilitated by the use of a HP 97 programme 'Water quality processing'. This programme is also used for checking the laboratory analysis (see chapter 3). The method of cross-checking the measured EC value against the concentration of cations and anions will therefore be included here.

The SAR value of an irrigation water is related to the equilibrium (long range) exchangeable sodium percentage, ESP, of the exchange complex of the soil irrigated with this water. The SAR is defined as follows:

$$SAR = \frac{[Na]}{\{[Ca + Mg]/2\}^{\frac{1}{2}}} \qquad (4\text{-}39)$$

where SAR-sodium adsorption ratio in $mmol^{\frac{1}{2}}.l^{-\frac{1}{2}}$

Permeability problems due to excess sodium or limited calcium can be evaluated using a new concept, the adjusted SAR:

$$adj.\ SAR = SAR\ (9.4 - pHc) \qquad (4\text{-}40)$$

where: adj. SAR = adjusted sodium adsorption ratio in $mmol^{\frac{1}{2}}.l^{-\frac{1}{2}}$

pHc = theoretical and calculated pHc value for equilibrium with lime

The pHc evaluates the tendency of the water to dissolve lime from the soil (pHc greater than 8.4) or to precipitate lime (pHc less than 8.4). The pHc in equation (4-40) is defined:

$$pHc = pK'_2 - pK'_c + p(Ca + Mg) + pAlk \qquad (4\text{-}41)$$

where: $pK'_2 - pK'_c$ is a function of [Ca + Mg + Na].
$p(Ca + Mg)$ is a function of [Ca + Mg]
pAlk is a function of $[CO_3 + HCO_3]$

$[Ca+Mg+Na]$ in meq l^{-1}	$pK'_2 - pK'_c$	$[Ca+Mg]$ in meq l^{-1}	$p(Ca+Mg)$	$[CO_3 + HCO_3]$ in meq/l^{-1}	pAlk
5.1	2.22	1.25	3.20	1.25	2.90
5.8	2.23	1.58	3.10	1.57	2.80
6.6	2.24	1.98	3.00	1.98	2.70
7.4	2.25	2.49	2.90	2.49	2.60
8.3	2.26	3.14	2.80	3.13	2.50
9.2	2.27	3.90	2.70	4.0	2.40
11	2.28	4.97	2.60	5.0	2.30
13	2.30	6.30	2.50	6.3	2.20
15	2.32	7.90	2.40	7.9	2.10
18	2.34	10.00	2.30	9.9	2.00
22	2.36	12.50	2.20	12.5	1.90
25	2.38	15.80	2.10	15.7	1.80
29	2.40	19.80	2.00	19.8	1.70
34	2.42				
39	2.44				
45	2.46				
51	2.48				
59	2.50				
67	2.52				
76	2.54				

Table 4-2. Tables for calculating the pHc of water (AYERS, 1977)

In table (4-2) tables of these functions are presented (AYERS, 1977).Using the data of this table the following empirical power relations have been found:

$$pK'_2 - pK'_c = 2.03144\ [Ca+Mg+Na]^{0.0502443} \qquad R^2 = 0.993 \qquad (4\text{-}42)$$

$$p(Ca+Mg) = 3.374208\ [Ca+Mg]^{-0.168965} \qquad R^2 = 0.996 \qquad (4\text{-}43)$$

$$pAlk = 3.08763\ [CO_3+HCO_3]^{-0.191873} \qquad R^2 = 0.994 \qquad (4\text{-}44)$$

*The concentrations are expressed in $meq.l^{-1}$. The electrical charges of the ions will be omitted in the ensuing text and formula's

The residual sodium carbonate is a parameter indicating the alkalinity hazard for the soil:

$RSC = [HCO_3+CO_3]-[Ca+Mg]$ if $[HCO_3+CO_3]-[Ca+Mg] > 0$

and $RSC = 0$ if $[HCO_3+CO_3]-[Ca+Mg] < 0$ (4-45)

where RSC = residual sodium carbonate in $meq.l^{-1}$

The total dissolved salts, TDS, expressed in $mg.l^{-1}$ (ppm) can be calculated by multiplication of the concentrations with the equivalent weights of the ions (see table 4-3).

Ion species	Equivalent weight
Ca	20.04
Mg	12.1525
Na	22.9398
K	39.102
CO_3	30.0046
HCO_3	61.0172
SO_4	48.0288
Cl	35.453

Table 4-3. Equivalent weights of common cations and anions, used in the HP 97 programme 'Water quality processing'

The measurement concentrations of cations and anions can also be used to calculate the EC of the drainage water. The chemical composition of the water is simplified to this purpose in the following way:

- the Ca and Mg ions are both considered as Ca
- the Na and K ions are considered as Na
- the HCO_3 and CO_3 ions are considered as HCO_3

The conductivity of single salt solutions is known (see fig. 4-9) from the literature (RICHARDS,1954). The following salts are considered:

- sodium bicarbonate, $NaHCO_3$
- sodium chloride, NaCl
- calcium chloride, $CaCl_2$
- di sodium sulphate, Na_2SO_4
- calcium sulphate, $CaSO_4$

For each of the salts considered empirical relations have been fitted through the curves given in fig. 4-9:

$$EC_S = 0.100250\ [NaHCO_3]^{0.942497} \qquad R^2 = 0.99991 \qquad (4\text{-}46)$$

$$EC_S = 0.135698\ [NaCl]^{0.948705} \qquad R^2 = 0.99989 \qquad (4\text{-}47)$$

$$EC_S = 0.132651\ [CaCl_2]^{0.943381} \qquad R^2 = 0.99997 \qquad (4\text{-}48)$$

$$EC_S = 0.132445\ [Na_2SO_4]^{0.920797} \qquad R^2 = 0.99982 \qquad (4\text{-}49)$$

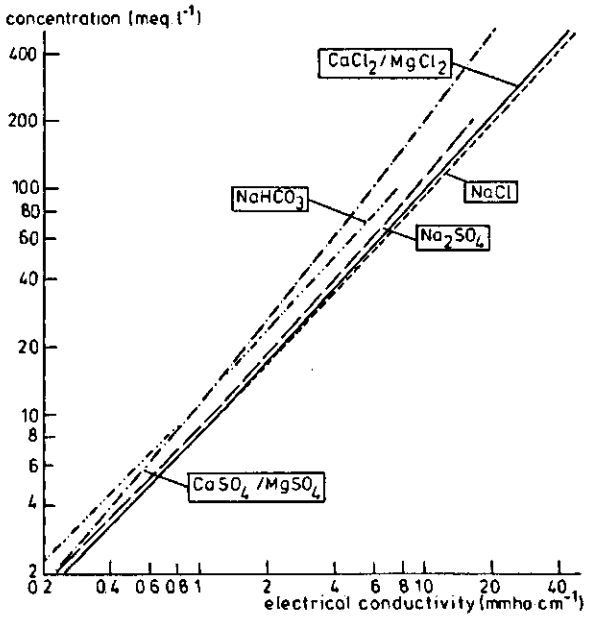


Fig. 4-9. Concentration of single salt solutions in milliequivalents per liter as related to electrical conductivity

$$EC_S = 0.134600\ [CaSO_4]^{0.82067} \qquad R^2 = 0.99995 \qquad (4\text{-}50)$$

where: EC_S = electrical conductivity of the single salt solution in $mmho.cm^{-1}$

The EC of a solution containing several salts can be assumed to be the sum of the contributions of the individual salts:

$$EC_M = \Sigma\ \Delta\ EC_{Si} \qquad (4\text{-}51)$$

where EC_M = electrical condu tivity of a solution containing several salts in $mmho.cm^{-1}$

ΔEC_{Si} = contribution of salts Si to the total EC_M in $mmho.cm^{-1}$

For the calculation of the ΔEC_{Si} a correction has to be applied for the ionic strength of the solution. Assuming the same interactions between ions of different species as for ions of the same species the following general form of equations (4-46) - (4-50) can be formulated:

$$\Delta EC_{Si} = \frac{[Si]}{\Sigma\ cat}\ a\ (\Sigma cat)^b \qquad (4\text{-}52)$$

where a and b are the constants of the relation for salt Si, defined in equations (4-46) - (4-50)

The allocation of the cations (2) and anions (3) to the salts Si (5) has been assumed as follows:

$[NaHCO_3]$ = [Na] if [Na] < $[HCO_3]$

= $[HCO_3]$ if [Na] > $[HCO_3]$ (4-53)

[NaCl] = [Na-$NaHCO_3$] if [Na-$NaHCO_3$] < [Cl]

= [Cl] if [Na-$NaHCO_3$] > [Cl] (4-54)

$[CaCl_2]$ = [Ca] if [Ca] < [Cl-NaCl]

= [Cl-NaCl] if [Ca] > [Cl-NaCl] (4-55)

$[Na_2SO_4]$ = [Na-$NaHCO_3$]-[NaCl] (4-56)

$[CaSO_4]$ = [Ca - $CaCl_2$] (4-57)

The equations (4-39) - (4-57) have been programmed for the HP 97 calculator. The programme operates in combination with a data card on which the constants of the empirical relations (4-42) - (4-44) and (4-46) - (4-50) have been compiled.

The following (key board controlled) subprogrammes can be distinguished (see annex 8.3 for the programme listing and the user instructions):

LBL A. In this subprogramme the concentration of cations is read (Ca, Mg, Na and K) and stored in the registers.

LBL B. This is the main programme. The concentration of anions (CO_3, HCO_3, SO_4 and Cl) are read and stored in the registers and the results (Σcat-Σan, SAR, adj. SAR, RSC, EC_c and TDS) are calculated and printed. The flow diagramme of both LBL A and LBL B is presented in fig. 4-10).

The complete calculation procedure for the water quality calculations is as follows:

1. Prepare the heading of the calculation sheet (for pump stations only, see annex 2). Record the observation year, catchment area(name of the drain at the outlet to the sea), the measurement point identification code and the calibration relation (if applicable). The preparation of the calculation sheets for open drains has been treated in chapter 4.1.1.2.
2. Check the EC measured in the laboratory with the EC measured in the field. If the difference between both is appreciable (more than 10 %) the chemical analyses of the water sample has to be repeated. If the whole series of measurements is deviating both the laboratory and the field EC meters have to be checked on the validity of the cell-constant (see chapter 3.1).
   If the repeated analysis results in the same deviations, attention should be paid to the possibility that water samples between two or more measuring points have been accidentally exchanged. Check the results for the same measurement date of the other measurement points.
3. Record the field observation date (not the date on which the sample has been transferred to the laboratory) on the calculation sheet. Round the concentrations of Ca, Mg, Na, K, CO_3, HCO_3 and Cl to the nearest digit behind the decimal point and record the rounded numbers on the calculation sheet. The pH should also be rounded to one digit behind the decimal point and the EC to two digits behind the decimal point and recorded on the calculation sheet.
4. Check the Na concentration and Cl concentration against the measured EC value using the relations found from the results of the previous observation year. Since 1980 has been the first year of observation no examples of this procedure can be given here. The general shape of such relations is given in fig. 3-2;chapter 3.
   If the data pairs (EC, Na) and/or(EC/Cl) are found outside the area enclosed by the lower and upper envelope curves the chemical analysis of the sample should be repeated. If such a repeated analysis gives the same results attention should be paid to the possibility that samples have been exchanged (see step 2).
5. Calculate the SO_4 concentration as the difference between cations and anions using the rounded numbers recorded on the calculation sheets, and record the result with one digit behind the decimal point on the calculation sheet. If the difference between the laboratory reported concentration and calculated SO_4 concentration is more than 0.2 meq. l^{-1} an error may have been made with the rounding off procedure. If the calculated SO_4 concentration is negative (see annex 2.7.2 measurements of 24/11/80) the chemical analysis should be repeated. If the repeated analysis gives the same results the (negative) SO_4 concentration should not be recorded and the steps 6 and 7 of this procedure may be omitted.
6. Check the EC against the calculated EC_c based on the cation and anion concentrations and calculate the SAR, adj. SAR, RSC and TDS using the HP 97 programme "Water quality processing" following the user instructions given in annex 7.3 (see also example 4-6). If the difference between EC_c and EC (measured) is less then 10 %, the calculated waterquality parameters SAR, adj. SAR and RSC are recorded on the calculation sheet with one digit behind the decimal point (dd.d) and the TDS rounded to the nearest 10 (this is automatically done by the HP 97 programme). If the difference between both is more than 10 % the chemical analysis of

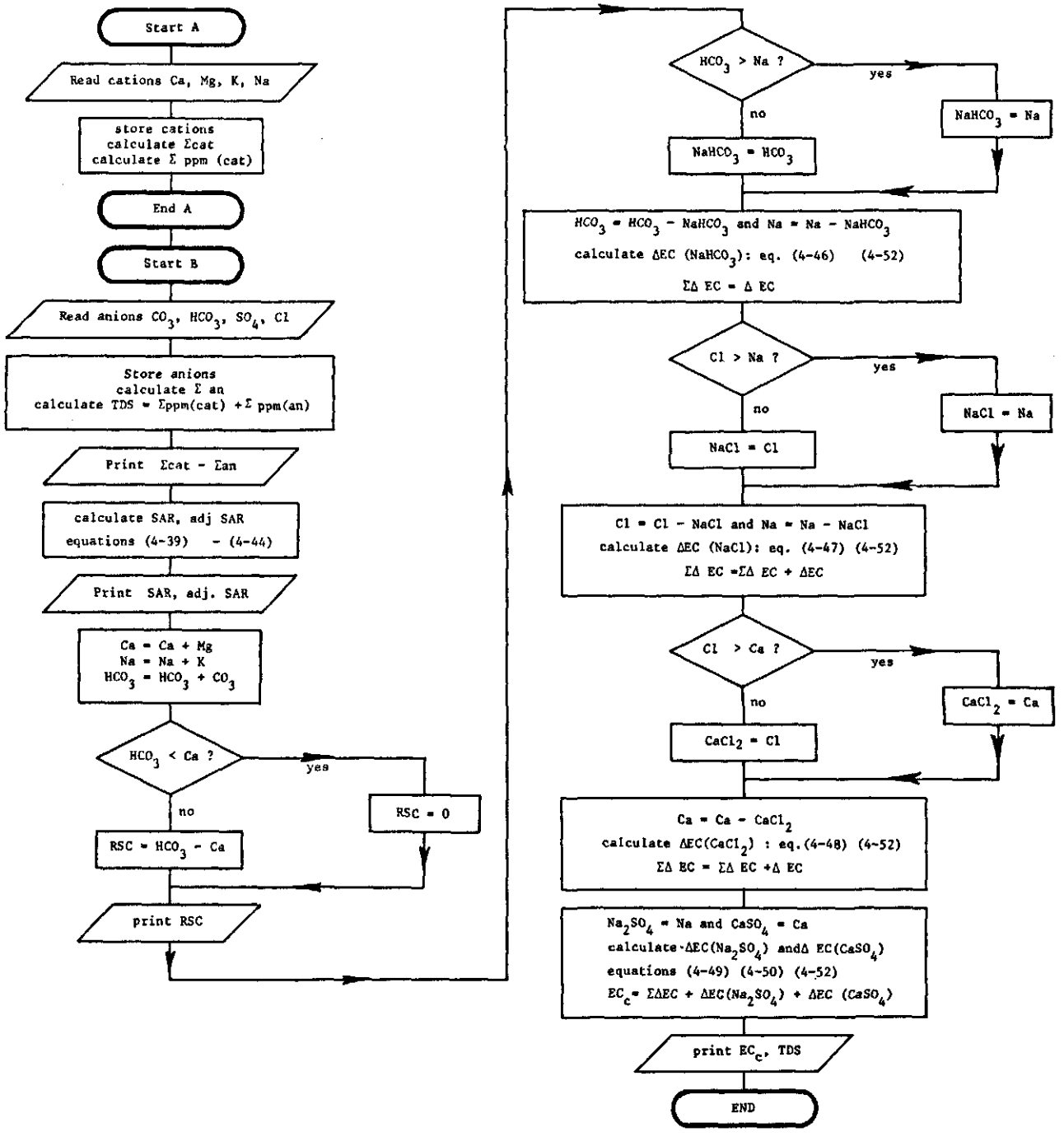


Fig. 4-10. Flow diagramme HP 97 programme
Water Quality processing'

Example 4-6. Water quality data processing (data from annex 2-1-2)

Input	Keys	Output	Comments
			Enter card with programme 'Water quality processing'
			Enter data card 'Water quality processing'
3.6	ENTER ↑		Ca concentration dd. 09/01/80
5.3	ENTER ↑		Mg concentration "
5.6	ENTER ↑		Na concentration "
0.1	A		K concentration "
0	ENTER ↑		CO_3 concentration "
4.2	ENTER ↑		HCO_3 concentration "
3.4	ENTER ↑		SO_4 concentration "
7	B	0.000000000	Cl concentration " (input); Σcat - Σan (output)
		2.7	SAR
		6.4	adj SAR
		0.0	RSC
		1.45	EC_c; the EC measured in the laboratory was 1.45
		940.	TDS in ppm
6.6	ENTER ↑		Ca concentration dd. 23/01/80
10.1	ENTER ↑		Mg concentration "
35	ENTER ↑		Na concentration "
0.7	A		K concentration "
0	ENTER ↑		CO_3 concentration "
5.3	ENTER ↑		HCO_3 concentration "
17	ENTER ↑		SO_4 concentration "
30.1	B	0.000000000	Cl concentration " (input); Σ cat - Σan (output)
		12.1	SAR
		31.3	adj. SAR
		0.0	RSC
		4.89	EC_c
		3290.	TDS ppm
3.85	ENTER ↑		EC measured in the laboratory
1.1	X	4.24	The EC measured is more than 10 % lower than the EC_c calculated

the sample should be repeated. If the repeated analysis gives the same results, the calculated water quality parameters are not recorded, and a positive sign (+) is recorded in the EC column of the calculation sheet if the measured EC is greater than the calculated EC_c and a negative sign (-) if EC is smaller than EC_c (see annex 2).

7. After all results of the observation year and the first set of observations of the next observation year have been recorded the calculation sheets have to be copied and the copy transferred to the department head for filling. It is important that this copy is stored seperately, because the data sheet contains the original processed data and they may be required in future for reference. On the original calculation sheet data may be added and/or changed as a result of the data consistency analyses (see chapter 5).

4.3. Calibration measurements processing (H. Meyer)

A distinction is made between the calibration data processing at pump stations and at open drains. In both cases the current meter measurements have to be translated into velocities, for which the factory calibrated relation is available for each wing:

$$v = a + b\,n \qquad (4\text{-}58)$$

where: v = velocity in $m.s^{-1}$

a and b = factory calibrated constants depending on the wing used

n = number of revolutions per seconds

If the measurement interval is Δt seconds, n is defined:

$$n = N/\Delta t \qquad (4\text{-}59)$$

where: N = number of revolutions during the pre-set time interval

Δt = measurement time interval in s.

The constant a en b that are factory calibrated when the meter is still new, have to be reconsidered after each period of operation of approximately one year. A recalibration has to be performed every year, or whenever damage to the instrument is suspected. The Hydraulics Research Institute at the Nile Delta Barrages (Ministry of Irrigation) has all necessary equipment to perform these calibrations.

4.3.1. Calibration measurements data processing at pump stations

Two types of measurements are performed at pump stations: level measurements to determine the suction head and current meter measurements to determine the discharge. The suction head can be calculated from the field observations:

$$\Delta H = \Delta h + Hm_s - Hm_d \qquad (4\text{-}60)$$

where: ΔH = suction head in m

Δh = level difference between fixed points at suction and delivery side in m

Hm_s = distance between waterlevel and fixed point at suction side in m

Hm_d = idem at delivery side

The level difference between the fixed points is determined by the level instrument readings (see fig. 2-12.:

$$h = Abs\ \{\Sigma(R_{back} - R_{forw})\} \qquad (4\text{-}61)$$

whwre: R_{back} = backward instrument reading

R_{forw} = forward instrument reading

Abs = absolute value of the expression between brackets

If the staff is placed on the suction side fixed point first, the summation in equation (4-61) will by positive, if the measurements start at the delivery side fixed point the summation will be negative.

The first current meter observation in a vertical is always performed at 0.25 m from the approach channel's bottom (see chapter 2.4.1) and the intervals between successive measurements is 0.50 m. When n measurements are performed in this way, the depth interval between the water surface and measurement n is given by:

$$d_{n+1} = D - 0.5\ n + 0.25 \qquad (4\text{-}62)$$

where: d_{n+1} = distance between the last measurement and the water surface in m (see fig. 4-11)

D = waterdepth in m

n = number of measurements performed in the vertical

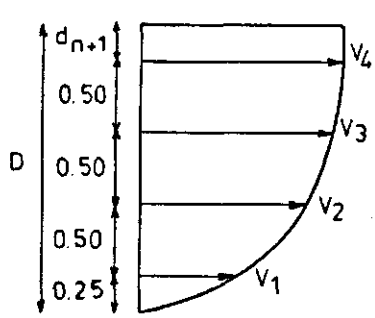


Fig. 4-11. Measurement intervals in the vertical at pump stations

Assuming that 50 % of the lowest depth interval (50 % of 25 cm) contributes to the discharge, the discharge per unit width of the vertical can be calculated by multiplying the velocities with the depth intervals:

$$q = 0{,}375\ v_1 + \sum_{i=2}^{n-1} 0.5\ v_i + (D+0.5 - 0.5n)v_n \qquad (4\text{-}63)$$

where q = discharge per unit width in $m^2.s^{-1}$

The average velocity in the vertical is obtained by dividing with D:

$$\bar{v} = q/D \qquad (4\text{-}64)$$

The verticals are measured at equal intervals and the distances between the side walls of the approach channels and the first and last vertical are equal and relatively small (see chapter 2.4.1.). Assuming that 2/3 of the first and last interval contribute to the discharge, the discharge through the approach channel can be calculated by multiplying the discharges per unit width with the width of the intervals:

$$Q = \frac{2\ W_o}{3}(q_1 + q_m) + \frac{W_m}{2}\sum_{i=1}^{m-1}(q_i + q_{i+1}) \qquad (4\text{-}65)$$

where: Q = discharge in $m^3.s^{-1}$

W_o = width of the first and last interval (between vertical and side wall) in m

m = number of verticals measured

W_m = width of the interval between verticals in m

The suction head discharge relation can be obtaind by linear regression analysis (standard HP 97 programme) using the data pairs (ΔH, Q):

$$Q = Q_o + S\ \Delta H \qquad (4\text{-}66)$$

where: Q_o and S are regression constants.

High correlation coefficients of equation (4-66) cannot be expected due to several reasons: there may be differences between the individual pump units; floating water plants (trashracks not completely clean) may disturb the measurements; and the ΔH range covered generally is rather limited.
The calculations are facilitated by the use of standard calculation sheets as will be shown below.

The complete procedure for the calculation of the suction head discharge relation of a pump station is as follows:

1. Calculate the difference between the level of the fixed points and calculate the average suction head during each measurement of a pump unit using equation (4-61) and (4-60). See example 4-7.
2. Prepare the heading of velocity calculation sheet. Record the name of the pump station, the pump unit number, the observation date, the wing identification number, the wing relation (4-58), the time interval, and the average suction head. See example (4-8). Record the distance of the verticals from the approach channel's side.

Example 4-7. Calculation Δh and ΔH (data from annex 1.6.5)
Using the HP 97 calculator the following procedure can be used

Input	Keys	Output	Comments
2.206	ENTER ↑		backward reading
0.284	−	1.92	forward reading (input); $R_{back} - R_{forw}$ (output)
1.478	ENTER ↑		R_{back}
1.040	−	0.44	R_{forw} (input); $R_{back} - R_{forw}$ (output)
	+	2.36	$\Delta h = \Sigma(R_{back} - R_{forw})$
2.36	ENTER ↑		Δh
0.71	+	3.07	Δh + Hm_s at 10.00 (pump unit 1 calibrated between 10.00 and 10.45
0.88	−	2.19	Δh + Hm_s − Hm_d at 10.00
2.36	ENTER ↑		Δh
0.66	+	3.02	Δh + Hm_s at 10.15
0.975	−	2.05	Δh + Hm_s − Hm_d at 10.15
	+	4.24	Σ
2.36	ENTER ↑		Δh
0.685	+	3.05	Δh + Hm_s at 10.30
1.03	−	2.02	Δh + Hm_s − Hm_d at 10.30
	+	6.25	Σ
2.36	ENTER ↑		Δh
0.68	+	3.04	Δh + Hm_s at 10.45
1.09	−	1.95	Δh + Hm_s − Hm_d at 10.45
	+	8.20	Σ
4	÷	2.05	ΔH = Σ ( )/4; 4 suction head measurements have been performed

Example 4-8. Calculation of current meter velocities at pump stations

The data used are the calibrations of pump unit 1, performed between 10.00 and 10.45 on 28/10/81 at Hanut pump station (annex 1.6.5)
The calculation sheet for these data is as follows:

LOCATION : Hanut pump station
PUMP UNIT NR : 1
OBSERVATION DATE: 28/10/81

WING NR : 1-68827
RELATION : v = 0.262 n + 0.006
TIME INTERVAL : 30 s
SUCTION HEAD ΔH: 2.05

Distance of vertical from side wall	0.125	0.625	1.125	1.625
	0.375 x 0.53 =	0.375 x 0.53 =	0.375 x 0.47 =	0.375 x 0.46 =
	0.5 x 0.33 =	0.5 x 0.33 =	0.5 x 0.51 =	0.5 x 0.36 =
	0.5 x 0.34 =	0.5 x 0.47 =	0.5 x 0.45 =	0.5 x 0.51 =
	0.5 x 0.45 =	0.5 x 0.56 =	0.5 x 0.54 =	0.5 x 0.46 =
	0.5 x 0.47 =	0.5 x 0.55 =	0.5 x 0.56 =	0.5 x 0.58 =
	0.5 x 0.53 =	0.5 x 0.55 =	0.5 x 0.48 =	0.5 x 0.50 =
	0.5 x =	0.5 x =	0.5 x =	0.5 x =
	0.5 x =	0.5 x =	0.5 x =	0.5 x =
	0.5 x =	0.5 x =	0.5 x =	0.5 x =
	0.5 x =	0.5 x =	0.5 x =	0.5 x =
	0.37 x 0.42 =	0.38 x 0.55 =	0.32 x 0.44 =	0.32 x 0.52 =
	+	+	+	+
	$\bar{v} = \frac{1.414}{3.37}$ *** = 0.420	$\bar{v} = \frac{1.638}{3.38}$ = 0.485	$\bar{v} = \frac{1.587}{3.32}$ = 0.478	$\bar{v} = \frac{1.544}{3.32}$ = 0.465

Distance of vertical from side wall	2.125	2.625	3.125	
	0.375 x 0.36 =	0.375 x 0.35 =	0.375 x 0.36 =	0.375 x =
	0.5 x 0.34 =	0.5 x 0.33 =	0.5 x 0.31 =	0.5 x =
	0.5 x 0.50 =	0.5 x 0.45 =	0.5 x 0.29 =	0.5 x =
	0.5 x 0.51 =	0.5 x 0.54 =	0.5 x 0.27 =	0.5 x =
	0.5 x 0.53 =	0.5 x 0.47 =	0.5 x 0.28 =	0.5 x =
	0.5 x 0.56 =	0.5 x 0.45 =	0.5 x 0.32 =	0.5 x =
	0.5 x =	0.5 x =	0.5 x =	0.5 x =
	0.5 x =	0.5 x =	0.5 x =	0.5 x =
	0.5 x =	0.5 x =	0.5 x =	0.5 x =
	0.5 x =	0.5 x =	0.5 x =	0.5 x =
	0.35 x 0.47 =	0.37 x 0.40 =	0.39 x 0.22 =	x =
	$\bar{v} = \frac{1.520}{3.35}$ = 0.454	$\bar{v} = \frac{1.399}{3.37}$ = 0.415	$\bar{v} = \frac{0.956}{3.39}$ = 0.282	$\bar{v} =$ ——— =

* $v_1 = 0.262\ (60/30) + 0.006 = 0.53$ (equations (4-61) and (4-60))

** $\Delta D = 0.25 + (D - 0.5 * 7 + 0.25)$ (equation (4-62))

*** $q = \Sigma \Delta D\ v$

\+ D, measured in the field

3. Calculate the velocities using equation (4-58) and (4-59), or a rating curve of these equations. Record the velocities on the calculation sheet (example 4-8) and calculate the discharge per unit width and the average velocity in the section. See example 4-8. Record the results on the calculation sheet. Use a seperate calculation sheet for each measurement of each pump unit.
4. Draw the velocity profiles in the verticals on mm paper (fig. 4-12). Indicate the vertical (distance from side wall) and record the average velocity calculated in step 3. Check (by eye) whether the calculated average velocity is correct. In the average velocity seems too high or too low, repeat the calculation of q and $\bar{v}$ (example 4-8). Make a separate graph with velocity profile for each measurement of each pump unit. Record on the graph the name of the pump station, the number of the pump unit, the average suction head during the measurement and the observation date (see fig. 4-12).
5. Prepare the heading of the discharge calculation sheet. Record the name of the pump station, the pump unit number and the observation date (see example 4-9).
6. Calculate the partial discharges through the sections measured and calculate the total discharge (equation (4-65)). Record the results on the calculation sheet. Record also the average suction head during the measurements. Use a seperate calculation sheet for each pump unit (2 measurements per sheet). See example 4-9.
7. Prepare a table of results (see annex 2.6.1) with the date of observation and the suction and discharge calculated of the pump units.
8. Calculate the calibration relation (equation (4-66)) using the standard curve fitting HP 97 programme. See example 4-10. Record the relation on the table of results. If great differences do occur between the discharges of the individual pump units (of different size), seperate calibration relations for these units have to be prepared.
   Record the relation also on the calculation sheet of the routine programme measurements.
9. Prepare a graph of the calibration measurements results including the calibration relation established (see fig. A 2-6, annex 2.6.1).
10. Transfer a copy of the table with results and the graph to the department head for the duplicate file. Store the field measurement forms, calculation sheets and the results in a filling cabinet.

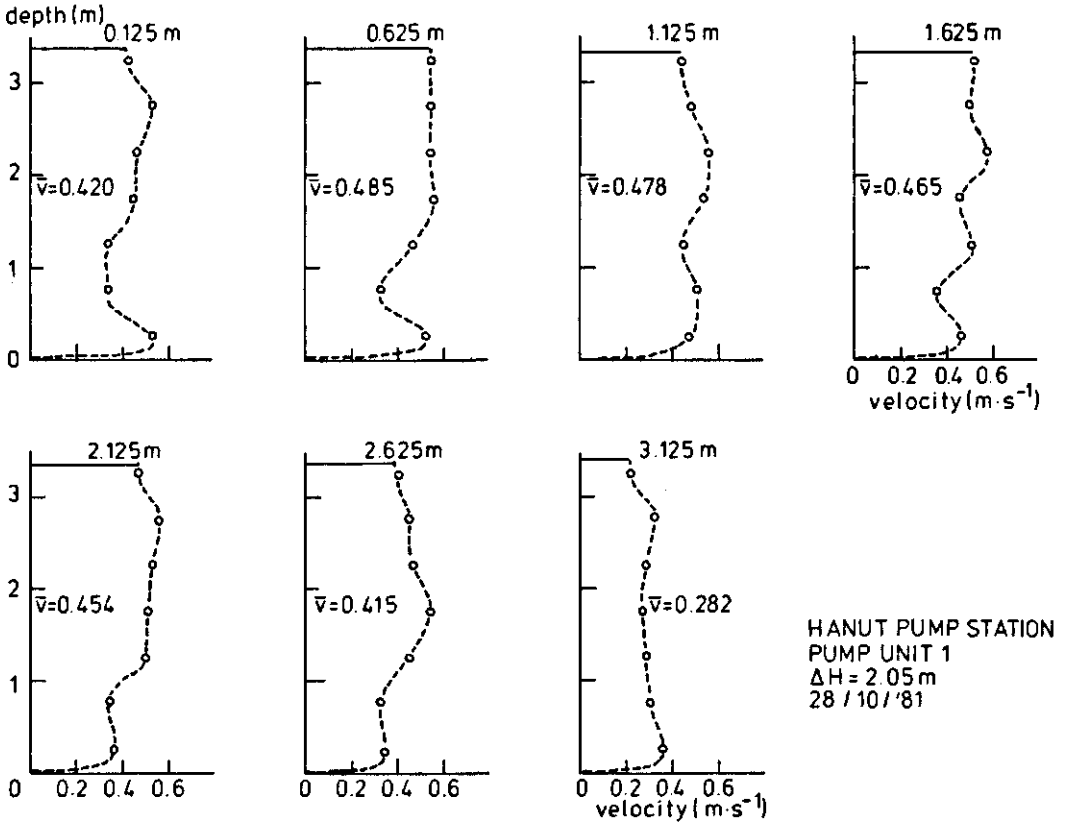


Fig. 4-12. Velocity profiles pump units 1 Hanut pump station (data from example 4-8)

Example 4-9. Calculation of discharge from current meter measurements at pump stations.

The data used are the calibrations of pump unit 1, performed between 10.00 and 10.45 on 28/10/81 at Hanut pump station (annex 1.6.5 and example 4-8)

The calculation sheet is as follows:

LOCATION : Hanut pump station

PUMP UNIT NR. : 1

OBSERVATION DATE: 28/10/81

2/3 x 0.125 *	x	1.414 **	= 0.118	2/3 x	x		=
0.5 x 0.5 ***	x	(1.414 + 1.638) +	= 0.763	0.5 x	x	(+)	=
0.5 x 0.5	x	(1.638 + 1.587)	= 0.806	0.5 x	x	(+)	=
0.5 x 0.5	x	(1.587 + 1.544)	= 0.783	0.5 x	x	(+)	=
0.5 x 0.5	x	(1.544 + 1.520)	= 0.766	0.5 x	x	(+)	=
0.5 x 0.5	x	(1.520 + 1.399)	= 0.730	0.5 x	x	(+)	=
0.5 x 0.5	x	(1.399 + 0.956)	= 0.589	0.5 x	x	(+)	=
0.5 x	x	(+)	=	0.5 x	x	(+)	=
2/3 x 0.125	x	0.965	= 0.080	2/3 x	x		=
			+				+
	ΔH = 2.05		Q = 4.64		ΔH =		Q =

* W_o = 0.125 m

** q_1 = 1.414 (see example 4-8)

*** W_m = 0.5 m

\+ $q_i + q_{i+1}$ (equation (4-65); example 4-8)

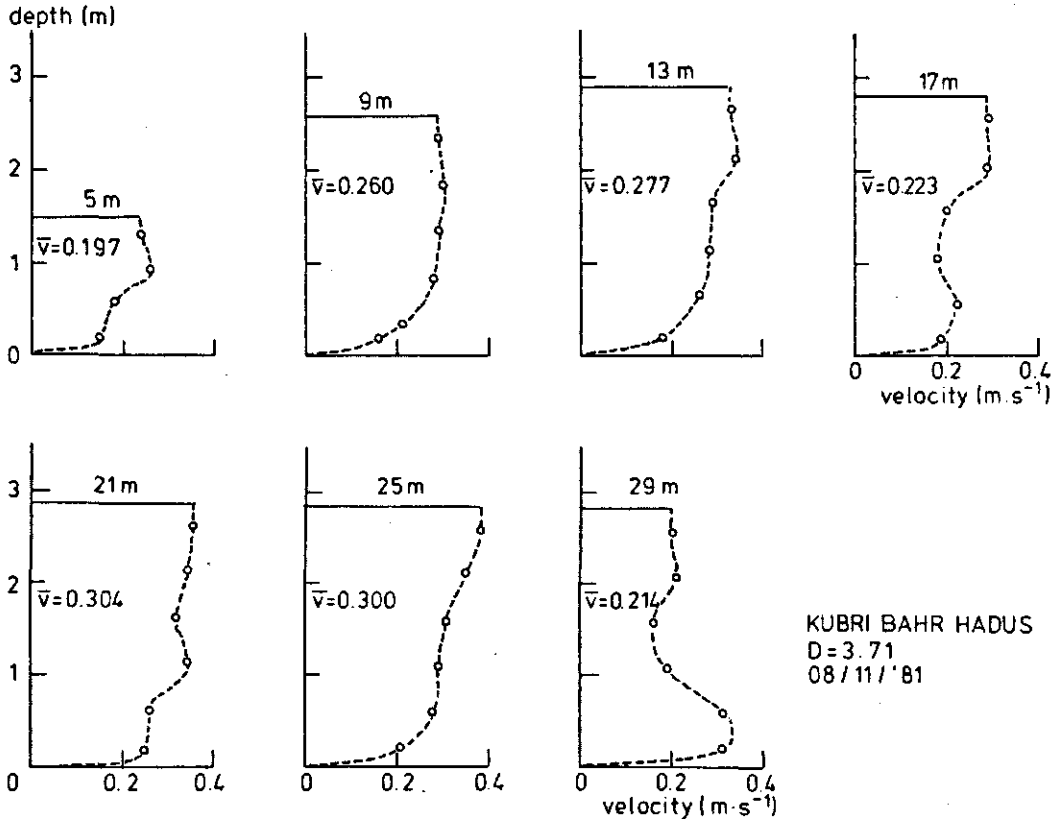


Fig. 4-13. Velocity profiles (5-29) 'Kubri Bahr Hadus' (data from example 4-11)

11. Once every year the calibration relation has to be checked on its validity. The procedure for checking is as follows:

- inquire at the pump station once every year (preferably shortly after the winter closure period) whether overhaul of pump units has been performed since the previous calibration or check;
- if one, or more units have been overhauled these units have to be re-calibrated. Always perform one measurement on a non-overhauled pump unit;
- calculate the suction head and discharge of the overhauld pump units and the non-overhauled unit used for checking following steps 1 - 6;
- check the discharge of the non-overhauled pump unit at the same suction head at the relation previously measured (fig. A 2-6, annex 2.6.1). To this purpose the two points determined during the previous calibration measurement are connected by a straight line and the discharge interpolated for the suction head of the measured discharge. If the difference between the measured and interpolated discharges is less than 5 %, the calibrations of the non-overhauled pump units can still be considered as reliable;
- if the non-overhauled unit is still reliable:
  + the calibration relation is still considered reliable if no overhaul has taken place. Indicate in this case on the table of results and the graph with the calibration relation the date of checking
  + the calibration relation has to be revised by replacing the measured data for the overhauled pump unit(s) following steps 7-10;
- if the non-overhauled unit is unreliable the measurements performed for checking and calibrating the overhauled units have to be completed (chapter 2.4.1) and the calculations proceed from step 1 through step 10.

4.3.2. Calibration measurements data processing at open drains

Four types of data are collected during the calibration measurements at open drains: current meter measurements, Hm measurements, float measurements and pendulum meter measurements.

The float measurements have been treated in chapter 4.1.1.2 and the pendulum meter measurements in chapter 4.1.1.3.

The total depth of the vertical measured from the boat can be calculated by adding the constant (= 0.20 m) distance between the suspended weight and the current meter to the depth reading taken from the counter on the reel:

$$D = 0.01\ D' + 0.2 \qquad (4\text{-}67)$$

where: D = depth of the vertical in m
D' = counter reading in cm

Due to the measurement procedures followed (see chapter 2.4.2) the equation for the discharge per unit width (4-63) valid for measurements at pump stations changes:

$$q = (0.1 + 0.01\ D'/7)\ v_1 + 0.02\ D'/7 \sum_{i=1}^{4} v_i \qquad \text{for } D' < 175 \qquad (4\text{-}68a)$$

and

$$q = (0.1 + 0.5d_1)v_1 + (0.5d_1 + 0.25)\ v_2 + \tfrac{1}{2} \sum_{i=3}^{n} v_i \qquad \text{for } D' > 175 \qquad (4\text{-}68b)$$

Example 4-10. Calculation calibration relation of Hanut pump station (data from annex 2.6.1)

Input	Keys	Output	Comments
			Enter programme card 'Curve fitting'
	f B	1	Select linear regression
2.05	ENTER ↑		ΔH unit 1 (low suction head)
4.65	A	2	corresponding Q unit 1
2.76	ENTER ↑		ΔH unit 1 (high suction head)
4.53	A	3	corresponding Q unit 1
1.88	ENTER ↑		ΔH unit 2 (low suction head)
5.13	A	4	corresponding Q unit 2
2.65	ENTER ↑		ΔH unit 2 (high suction head)
4.70	A	5	corresponding Q unit 2
1.82	ENTER ↑		ΔH unit 3 (low suction head)
5.36	A	6	corresponding Q unit 3
2.44	ENTER ↑		ΔH unit 3 (high suction head)
4.82	A	7	corresponding Q unit 3
	C	0.63	correlation coefficient R
		6.28	y-axis intercept Q_o
		- 0.63	slope S = dQ/d (ΔH)

where: v_1 = velocity at 0.2 m from the drain bottom in $m.s^{-1}$

d_1 = length of the second depth interval in m (length between observation v_1 and v_2; see fig. 2-16)

n = number of velocity observations in the vertical

If the total water depth of the vertical is less than 1.95 m (D' < 175) four velocity observations are performed at equal intervals of D'/3.5 cm with the first observation at 0.2 m from the bottom and the last observation at D'/7 cm from the water surface, and equation (4-68a) has to be used. If the total water depth in the vertical is more than 1.95 m (D' > 175) the number of velocity observations in the vertical may be 4 or more, taken at equal intervals of 0.50 m, with the last measurement at 0.25 cm from the water surface. Since the first measurement has been taken at 0.20 m from the drain bottom, the number of measurements n is given by:

$$n = \text{Int}\ (0.5\ D - 0.23) + 2 \qquad (4\text{-}69)$$

where: Int ( ) = integer function, takes the integer quantity of the expression between brackets

The length of the second interval follows from n and D:

$$d_1 = D - 0.5\ n + 0.55 \qquad (4\text{-}70)$$

Due to the fact that the water depth is zero near the banks of the drain (in the approach channel at pump stations the water depth near the side walls has been considered equal to the water depth in the first respectively last interval) the factor 2/3 in equation (4-65) has to be multiplied with 1/2:

$$Q = 1/3\ (W_o q_1 + W_m q_m) + 1/2 \sum_{i=1}^{m-1} W_i (q_i + q_{i+1}) \qquad (4\text{-}71)$$

where: W_o = distance between first vertical and embankment (water depth = 0) in m

q_1 = discharge per unit width through the first vertical $m^2.s^{-1}$

W_m = distance between last vertical and embankment

m = number of verticals measured

W_i = distance between vertical i and vertical i+1

On the condition that the wetted cross-section changes regularly with depth (no sudden changes in roughness coefficient due to side banks overflow) and no back water effects do occur, the stage-discharge relation has the following general form (LAMBIE, 1978):

$$Q = a\ D^b \qquad (4\text{-}72)$$

where: a = discharge coefficient

D = water depth in m with respect to reference datum (depth at with Q is zero)

b = discharge exponent

Equation (4-72) can be established using the standard HP 97 programme 'Curve fitting'. Depending on the amount of hysteresis* more observations have to be performed to obtain a reliable stage-discharge relation.

Because the effects of hysteresis and of backwater effects on the stage-discharge relation cannot be distinguished when a limited amount of (D, Q) data pairs have been used for establishing the relation (4-72), an increasing amount of calibration measurements is required when hysteresis is considerably. Using the correlation coefficient as a yard stick the following table can be tentatively used for the number of calibration measurements required

Number of calibrations required	Correlation coefficient relation reliable	relation unreliable
minimum 5	$R^2 > 0.95$	$R^2 < 0.45$
5 < n < 10	$0.90 < R^2 < 0.95$	$R^2 < 0.55$
10 < n < 15	$0.85 < R^2 < 0.90$	$R^2 < 0.65$
15 < n < 20	$0.75 < R^2 < 0.85$	$R^2 < 0.75$

Table 4-4. Required number of calibrations for open drains

If backwater effects do invalidate the stage-discharge relation (4-72) the general formula for discharge has to be used:

$$Q = A.\bar{v} \qquad (4\text{-}73)$$

where: A = wetted cross-section in m^2

$\bar{v}$ = average velocity in the cross-section

The average velocity in equation (4-73) may be related to the average velocity in a reference vertical:

$$\bar{v} = a + b\ \bar{v}_p \qquad (4\text{-}74)$$

where a and b are regression constants

$\bar{v}_p$ = average (pendulum) velocity in a reference vertical in $m.s^{-1}$

The complete calculation procedure for the calibration measurements at open drains measurement locations is as follows:

1. Calculate the water depth at the reference point, the wetted cross-sectional area, the discharge and the average float velocity from the float measure-

* Hysteresis is due to the fact that during a rising flood the slope of the flood wave front is significant steeper than the steady-state hydraulic gradient, and during recession the water slope is flatter. As a result the discharge on a rising stage is substantially higher than the discharge on the same, but falling, stage

Example 4-11. Calculation of current meter velocity at open drain locations

The data used are the calibration of the Bahr Hadus drain 'Kubri Bahr Hadus' performed on 08/11/81 (annex 1.7.5)

The first page of the calculation sheets for these data is as follows:

LOCATION : 'Kubri Bahr Hadus'
DATE : 8/11/81
WATERDEPTH : 3.71

WING NR. : 1-68838
RELATION : v = 0.262 n + 0.006
TIME INTERVAL : 25.6 s

Distance from the left bank facing the bridge

0			5			9			13		
(0.1+	)x	=	(0.1+0.186)*	x 0.15+	=	(0.1 +0.075x)	x 0.16	=	(0.1 +0.22)	x 0.18	=
(	)·	=	(0.371**	)x 0.18	=	(0.25+0.075	)x 0.21	=	(0.25+0.22)	x 0.26	=
(	)x	=	(0.371	)x 0.26	=	(0.5	)x 0.28	=	(0.5	)x 0.28	=
(	)x	=	(0.371	)x 0.24	=	(0.5	)x 0.29	=	(0.5	)x 0.29	=
0.5	x	=	0.5	x	=	0.5	x 0.30	=	0.5	x 0.34	=
0.5	x	=	0.5	x	=	0.5	x 0.29	=	0.5	x 0.33	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
	+			+			+			+	
$\bar{v} = \frac{}{D=0} = 0$***			$\bar{v} = \frac{0.295}{1.50}$++ = 0.197			$\bar{v} = \frac{0.676}{2.60} = 0.260$			$\bar{v} = \frac{0.800}{2.89} = 0.277$		

Distance from the left bank facing the bridge

17			21			25			29		
(0.1 +0.175)	x0.19	=	(0.1 +0.21)	x0.25	=	(0.1 +0.195)	x 0.21	=	(0.1 +0.19)	x 0.31	=
(0.25+0.175)	x0.22	=	(0.25+0.21)	x0.26	=	(0.25+0.195)	x 0.28		(0.25+0.19)	x 0.31	=
(0.5	)x0.18	=	(0.5	)x0.34	=	(0.5	) x 0.29	=	(0.5	)x 0.19	=
(0.5	)x0.20	=	(0.5	)x0.32	=	(0.5	) x 0.31	=	(0.5	)x 0.16	=
0.5	x0.29	=	0.5	x0.34	=	0.5	x 0.35	=	0.5	x 0.21	=
0.5	x0.29	=	0.5	x0.35	=	0.5	x 0.38	=	0.5	x 0.20	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
0.5	x	=	0.5	x	=	0.5	x	=	0.5	x	=
	+			+			+			+	
$\bar{v} = \frac{0.626}{2.80} = 0.223$			$\bar{v} = \frac{0.872}{2.87} = 0.304$			$\bar{v} = \frac{0.852}{2.84} = 0.300$			$\bar{v} = \frac{0.606}{2.83} = 0.214$		

* 0.01 D'/7 = 1.3/7 = 0.186
** 0.02 D'/7 = 2.6/7 = 0.371
*** D = 0; v = 0, this is the boundary of side bank with water surface
\+ v = 0.262 n + 0.06 = 0.262 (14/25.6) + 0.06 = 0.15
++ q = $\Sigma \Delta dv = 0.295\ m^2.s^{-1}$
+++ D = 0.01 D' + 0.2 = 0.01 x 1.30 + 0.2 = 1.50
x $0.5\ d_1 = 0.5\ (D - 0.5\ n + 0.55) = 0.5\ (2.60 - 0.5 \times 6 + 0.55) = 0.075$

Example 4-12. Calculation of discharge from current meter measurements at open drains

The data used are the calibration of 'Kubri Bahr Hadus', performed on 08/11/81 (annex 1.75 and example 4-11)

The calculation sheet is as follows:

LOCATION : Kubri Bahr Hadus
OBSERVATION DATE: 7/11/81
WATER DEPTH : D = 3.71

			Comments
1/3 x 5	x 0.295	= 0.295	$\Delta Q = 1/3\ W_o q_1$
0.5 x 4	x (0.295 + 0.676)	= 1.942	$\Delta Q = 0.5\ W_1\ (q_1 + q_2)$
0.5 x 4	x (0.676 + 0.800)	= 2.952	$\Delta Q = 0.5\ W_2\ (q_2 + q_3)$
0.5 x 4	x (0.800 + 0.626)	= 2.852	
0.5 x 4	x (0.626 + 0.872)	= 2.996	etc.
0.5 x 4	x (0.872 + 0.852)	= 3.448	
0.5 x 4	x (0.852 + 0.606)	= 3.024	
0.5 x 4	x (0.606 + 1.018)	= 3.248	
0.5 x 4	x (1.018 + 0.763)	= 3.562	
0.5 x 4	x (0.763 + 0.233)	= 1.992	
0.5 x 4	x (0.233 + 0.207)	= 0.880	
0.5 x 4	x (0.207 + 0.978)	= 2.370	
0.5 x 4	x (0.978 + 0.979)	= 3.914	
0.5 x 4	x (0.979 + 0.410)	= 2.778	
0.5 x 4	x (0.410 + 0.464)	= 1.784	
0.5 x 1	x (0.464 + 0.172)	= 1.272	$W_{16} = 1$ m
0.5 x	x (0.172 ± 0.035)	= 0.104	
0.5 x	x	=	
0.5 x	x	=	
0.5 x	x	=	
1/3 x 3	x 0.035	= 0.035	$\Delta Q = 1/3\ W_{17}\ q_{17}$ (m = 17)
		+	
	Q	= 39.61	

ments. Calculate the water depth at the reference point and the average pendulum velocity at this point. Follow the instructions given in chapter 4.1.1.2 for the float measurements and in chapter 4.1.1.3. for the pendulum measurements.

2. Prepare the table of results (first calibration measurement only) and record the measurement date, observation time, water depth D, discharge calculated with float method ($Qf = A\,\bar{v}f$), wetted area A, average float velocity $\bar{v}_f$ and average pendulum velocity $\bar{v}_p$ (see annex 2.7.3).
3. Calculate the average water depth D, during the current meter observation period, and record the result in the table (annex 2.7.3). Calculate the corresponding wetted cross-sectional area of the routine measurement point, A, and record the result (annex 2.7.3).
4. Prepare the heading of the calculation sheets for average velocity in the vertical and record the name of the location, observation date, water depth at reference point, current meter wing number, wing relation and time interval (see example 4-11). In general, more than one sheet will be required.
5. Calculate the depth of the interval (equation (4-67)) and record on the calculation sheet. Include the (not-measured) verticals at the banks of the drain where D = 0 (see example 4-11). Calculate the velocity from the current meter observations (equation (4-58)) and record the results on the calculation sheets (see example 4-11). Calculate and record the depth intervals for the calculation of discharge per unit width. Calculate the discharge per unit width for each vertical (equation (4-68)) and the average velocity (equation (4-64)) and record the results on the calculation sheet (see example 4-11).
6. Prepare graph's with the velocity profiles (fig. 4-13). Indicate the vertical (distance from location with zero water depth) and record the average velocity calculated in step 5. Check (by eye) whether the calculated average velocity is correct and repeat the calculation in step 5 if necessary. Record on the graph's the name of the measurement location, the observation date and the average water depth at the reference point.
7. Prepare the heading of the discharge calculation sheet. Record the name of the measurement location, the observation date and the water depth at reference point (see example 4-12).
8. Calculate the partial discharges through the sections measured and calculate the total discharge (equation (4-71)). Record the results on the calculation sheet (see example 4-12).
9. Calculate the average velocity in the routine programme measurement cross-section by dividing the discharge calculated from the calibration measurement by A. Record discharge and average velocity in the table of results (see annex 2.7.3).
10. Prepare graph's with results:
    - a plot of D against Q (see fig. A 2-8, annex 2.7.3)
    - a plot of $\bar{v}$ against $\bar{v}_f$ (see fig. A 2-9, annex 2.7.3)
    - a plot of $\bar{v}$ against $\bar{v}_p$ (see fig. A 2-10, annex 2.7.4)
11. If 5 or more calibrations have been performed the stage-discharge relation (4-72) can be determined using the (D, Q) data pairs and the standard HP 97 programme 'Curve fitting'. See example 4-10 for the operation of this programme and press fE instead of fB to select the power curve fit option. Compare the correlation coefficient obtained with those presented in table 4-4.
    - If the calculated correlation coefficient indicates that the relation is reliable for the number of observations made perform the following activities:
      + draw the calibration curve in fig. A 2-8 and record the expression of this relation on the graph including the correlation coefficient found;
      + make a copy of this figure and transfer the copy to the department head for the duplicate file;
      + record the calibration relation on the routine measurement calculation sheet.
    - If the calculated correlation coefficient indicates that the relation is unreliable for the number of observations made perform the following activities:
      + establish the $\bar{v} - \bar{v}_p$ relation (4-74) using the data pairs ($\bar{v}$, $\bar{v}_p$) presented in the table of results (see annex 2.7.3) and using the standard HP 97 programme 'Curve fitting' with the linear regression line option (see example 4-10);
      + draw the relation in fig. A 2-10 (annex 2.7.3 and record the expression for this relation on the graph including the correlation coefficient;
      + make a copy of both figs. A8 - 10 and A 2-10 and transfer the copy to the department head for the duplicate file;
      + record the relation (4-74) found on the routine measurement calculation sheet as the calibration relation.

- If the calculated correlation coefficient indicates that the relation is not reliable and not unreliable for the number of observations performed, more observations have to be done (n has to be increased).

12. Once the calibration relation (4-72) or (4-74) has been established on a yearly basis a calibration measurement has to be performed to check the validity of the relation.
If the result of such a routine check, processed following the step 1 - 8 is seriously deviating from the relation in fig. A 2-8 or A2-10 (see annex 2.7.3), another measurement has to be performed. If also these results are deviating the calibration of the measurement location has to start from scratch and should be completed within a period of one year in order not to hamper the data presentation (treated in chapter 6).
If the results of the check measurement is not deviating, the data pair (D, Q) or ($\bar{v}$, $\bar{v}_p$) collected can be included in the relation and the data processing procedure is complemented with the steps 9 - 11.

5. DATA CONSISTENCY ANALYSIS

The purpose of the data consistency analysis is to check the processed data on reliability and consistency, to find empirical relations between certain quantities measured, and to correct unreliable and inconsistent data using these empirical relations.
It must be realized that the correction of these data should be considered very carefully; when corrections are applied too liberally, the result may become more unreliable instead of more reliable.

When measurements are made the results of the measurements normally deviate from reality. This may be due to one or more of the following types of error: random errors; systematic errors; and spurious errors.

- Random errors are due to the limited reading accuracy of the instruments that are used and/or the human beings performing the measurements. Random errors have the pleasant property to 'average out'. That is, if sufficient measurements are taken, the random error will disappear from the calculated average. When two measured parameters, that have a physical relationship, are plotted against each other random errors will cause a scatter of data points around the relationship. Although it is not possible to delete random errors from single measurements (except by taking several measuremqnts and calculating the average) by data consistency analysis it may be possible in some cases to delete a method of measurement by comparing the amount of scatter. This is the case when comparing the discharge calculated from float measurements with the discharge calculated from pendulum measurements. Comparison of both discharges with the measured stage (Q - h relationship) allows to choose the method with the least amount of scatter (i.e. with the lowest random errors). Which one of both methods is better, depends on the characteristics of the measuring point in question. In general, a deep and narrow wetted cross-section will favour the pendulum meter measurements and a shallow and wide wetted cross-section will favour the float measurements.
Irregularities in the open channel profile, both in the cross-section and in the flow direction, generally will disqualify the pendulum measurements due to the measurement difficulties caused by these irregularities.
- Systematic errors may be due to several reasons. Normally, they are inherent to the method of measurement used. Also a shift in the reference datum of a certain variable or a certain instrument

will cause a systematic error. Systematic errors cannot be reduced by performing more measurements and calculating the average. Systematic errors may be a constant, a shift, or a function of one or more related measurements:

$R = M * C$ (constant)

$R = M + C$ (shift)

$R = f(M, Mi)$ (function)

where: R = real value of the quantity measured
M = measurement
C = constant
Mi = measurement of other quantity Ri, related to R

Removal of systematic errors can be done by the changing over to better methods for measuring or by correction. The correction to be applied can be found by comparing the method of measurement used with another, better, method. This is the case when calculating the correction to be applied for the float measurements. The relation of the current meter measurements with stage is divided by the relation of float measurements with stage resulting in a correction factor that is generally also a function of stage.
Another example of a systematic error correction, also stage dependent, is the correction for pump efficiency of the discharge at pump stations.

- Spurious errors are errors caused by instrument failure and human mistakes. Spurious errors, generally, invalidate the measurement performed. Date consistency analysis is specifically suited to detect this type of errors. Spurious errors have to be either completely removed, or be replaced by an estimate. Spurious errors may be caused by any of the following reasons: exchange of some or all of the discharge measurements between two stations; reporting wrong resistance body type for pendulum meter measurements; wrong scale factor when performing an instrument reading; etc.

In this chapter the methods developed for data consistency analysis for the fortnightly measurement programme will be treated and the ways to improve the data indicated. When applying the procedures presented, it is important to keep good track of the data and proper documentation of the calculations performed is of atmost importance. The measurement points to be considered for data checking have to be analysed in a certain sequence (see annex 4) proceeding from upstream to downstream direction per catchment area. In this way the checked and corrected data of the upstream measurement point can serve as a base for comparison of the data of the downstream measurement point.

The data consistency analyses have to be performed following the procedure given below, and according to the measurement point hierarchy given in annex 4:

1. After calculation of all data of the observation year under consideration (including the data for the first observation date of the next year) the calculation sheets have to be copied and the copies tranferred to the department head for the duplicate file.
2. For open drains where both float and pendulum measurements have been performed only:
   Check the pendulum constant C_p, used for the calculation of discharge. This will be treated in chapter 5.1.1.1.
   If the new pendulum constant differs more than 5 % from the old pendulum constant, the discharges have to be recalculated after considering the next step.
3. For open drains only:
   Check the correction factor C_D' used for the calculation of discharges. This will be treated in chapter 5.1.1.2.
   If the new factor C_D' differs more than 5 % from the old correction for the depth range of interest and/or if the new pendulum constant differs more than 5 % from the old pendulum constant the discharges have to be recalculated.
4. For open drains only:
   Identify unreliable (Q, D) data pairs using the empirical stage discharge curve. This will be treated in chapter 5.1.2.
5. For open drains (both measurement points) only:
   Identify unreliable water depth observation using the empirical double mass curves relating the water depth of different measurement points (see hierarchy in annex 4). This will be treated in chapter 5.1.3.
6. For all measurement points except irrigation pump stations*:
   Identify unreliable discharge observations using the empirical double mass curves relating the discharges of different measurement points (see hierarchy in annex 4). This will be treated in chapter 5.1.3.
7. For all measurement points except irrigation pump stations:
   Apply preliminary corrections to the D and/or Q

* An irrigation pump station is defined in this context as a pump station pumping (part of) the drainage water discharging from the catchment area into an irrigation canal.

observations that have been identified as unreliable. This will be treated in chapter 5.1.3.

8. For all measurement points:
   Identify unreliable EC measurements on the basis of consistency with the chemical analysis using the HP 97 programme 'Water Quality Processing' This has been treated in chapter 4.2.
9. For all measurement points:
   Identify unreliable (EC, Na) data pairs using the empirical relation between EC and Na-concentration. This will be treated in chapter 5.2.
10. For all measurement points:
    Identify unreliable (EC, Cl) data pairs using the empirical relation between EC and Cl-concentration. This will be treated in chapter 5.2.
11. For all measurement points:
    Apply preliminary corrections to the EC, Na- and/or Cl-concentrations that have been identified as unreliable. This will be treated in chapter 5.2.
12. For all measurement points:
    Check the preliminary corrections applied to the unreliable EC values using the empirical double mass curve relating the EC of different measurement points (see hierarchy in annex 4). This will be treated in chapter 5.3.
13. For alle measurement points, except irrigation pump stations:
    Check the corrections previously applied to the unreliable D, Q, Na-, and Cl-concentration values using the empirical double mess curves relating the Na load and the Cl load of different measurement points (see hierarchy in annex 4).
    If one, or both of the measurement points is an irrigation pump station the empirical relation between the Na-concentration and the Cl-concentration of different measurement points has to be used instead. In this case the correction of discharges cannot be performed. This matter will be treated in chapter 5.3.

5.1. Water quantity consistency analysis

This chapter is subdivided into three seperate parts. In the first part the choice between the calculation of discharges using the float measurements or using the pendulum measurements will be treated, based on the amount of random error associated with both methods. In the second part the identification of unreliable data will be treated and in the third part the preliminary correction of these data.

5.1.1. Random and systematic error

Minimizing the random error in the discharge measurements in open drains where both float measurements and pendulum measurements have been performed and determination of the systematic error in the discharge measured according to the fortnightly routine programme by comparison with the calibration measurements will be treated here.

5.1.1.1. Float-pendulum relation

The relation between the average 'float' velocity and the average 'pendulum' velocity has been formulated in chapter 4 (equation(4-33)):

$$\bar{v}_f = c_p \bar{v}_p \qquad (5\text{-}1)$$

where: $\bar{v}_f$ = average velocity in $m.s^{-1}$ in the routine measurement cross-section, based on float measurements (eq. 4-11)

c_p = pendulum constant

$\bar{v}_p$ = average velocity in $m.s^{-1}$ at the routine measurement reference point, based on pendulum meter measurements (eq. 4-23 '4-31 or 4-32)

The general equation for the stage discharge relation has been given in chapter 4.3 (equation 4-72):

$$Q = a\, D^b \qquad (5\text{-}2)$$

where: Q = discharge in $m^3.s^{-1}$

a = discharge coefficient

D = water depth in m with respect to reference datum

b = discharge exponent

The coefficients a en b can be found by regression analysis if a number of (Q,D) data pairs are known. Using the discharges calculated from the float measurements as input the results of the regression analysis is:

$$Qf = af\, D^{bf} \text{ with correlation coefficient } R^2f \qquad (5\text{-}2a)$$

where Qf = discharge calculated from the float measurements in $m^3.s^{-1}$ (equation 4-13)

When using the discharges calculated from the pendulum meter measurements equation (5-2a) changes:

$$Qp = ap\, D^{bp} \text{ with correlation coefficient } R^2p \qquad (5\text{-}2b)$$

where Qp = discharge in $m^3.s^{-1}$ calculated from the pendulum meter observations (equation 4-34)

The correlation coefficients R^2f and R^2p are measures for the 'goodness of fit' of the relations (5-2a) and (5-2b) to the data pairs (Qf,D) and (Qp,D) used for establishing the relations. More specific, the correlation coefficient gives the ratio between the explained variation and the total variation (M.R. SPIEGEL, 1961):

$$R^2 = \frac{\Sigma(Qest - \bar{Q})^2}{\Sigma(Q - \bar{Q})^2} \qquad (5\text{-}3)$$

where: Qest = discharge estimated with the relation established (equation 5-2a or 5-2b)

$\bar{Q}$ = average discharge of all observations used for establishing the relation

Q = measured discahrge

It follows from the definition of R^2 that the measurement method the smallest random error will show a higher correlation coefficient (less scatter of the data pairs (Q, D) around the relation found).

The complete procedure for selection of the best-fit measurement method is as follows: for open drains where both float measurements and pendulum measurements have been performed):

1. Make a plot of $\bar{v}_f$ against $\bar{v}_p$ using the data from the calculation sheet (see fig. 5-1).
2. Identify data pairs ($\bar{v}_f$, $\bar{v}_p$) that are far outside the swarm of points in this plot (see fig. 5-2).
   Check the calculations for these unreliable points. If the calculations have been performed correctly, repeat the calculations using a different resistance body type. If this checking and recalculation do not bring the unreliable point well inside the cluster of points (see fig. 5-2), remove the pendulum meter results from the calculation sheet and do not consider the point for the following steps.
3. Calculate the average float velocity and the average pendulum velocity using all measurements during the observation year for the dates on which both the float and pendulum measurements have been performed, and have been considered reliable or have been corrected (step 2). See example 5-1. Use 3 digits behind the decimal point for the velocities.
4. Calculate the pendulum constant $c_p = \bar{v}_f/\bar{v}_p$ by dividing the average float velocity by the average pendulum velocity found. Use 3 digits behind the decimal point.
5. Draw the relation ($\bar{v}_f = c_p \bar{v}_p$) in the figure (see fig. 5-3), record the c_p value on the graph and decide on additional unreliable points. Only points that are far outside the cluster of data points may be considered unreliable and removed or corrected. If so, repeat steps 2 - 4 for these points.
6. Check the pendulum constant against the pendulum constant found during last year. If the deviation is more than 5 % the new constant is recorded on the calculation sheet (c_p(new)/c_p(old) < 0.95 or c_p(new)/c_p(old) > 1.05).
7. Prepare a list of water depth D, discharge calculated from the float measurements $Q_f = c'_D \bar{v}_f A$ and discharge calculated from the pendulum measurements $Qp = c_p c'_D \bar{v}_p A$ for the measurement dates on which both float and pendulum measurements have been performed that have been considered as reliable or have been corrected (see example 5-1).
8. Calculate the correlation coefficients R^2f and R^2p using the (D,Q_f) and (D,Q_p) data pairs respectively and the standard HP programme 'Curve fitting' with the power curve option (press f E). See example (5-1).
   The method with the highest correlation coefficient can be considered as the more reliable method (least amount of scatter). If the correlation coefficients are equal (2 digits behind the decimal point) the method used for the previous year's calculations should be chosen.
9. If the float method has been chosen as the more reliable method (less random error) the c_p constant recorded on the calculation sheet (step 6) has to be removed.

5.1.1.2. Routine measurement - calibration measurement relation

By comparison of the discharges calculated from the routine measurements with the discharge measured with the current meter the systematic error in the routine measurements can be eliminated, or at least be reduced. The comparison between both methods is done by comparing the stage discharge relations (eq. 5-2):

$$Q_R = a\, D^b \qquad \text{for } R^2 > 0.50 \qquad (5\text{-}4a)$$

for the routine measurements,

where: Q_R = routine discharges, calculated from the float measurements, pendulum measurements, or a combination of both

and

$$Q_c = a_c\, D^{b_c} \qquad \text{for } R^2 > 0.50 \text{ and } n > 3 \qquad (5\text{-}4b)$$

for the calibration measurements

where Q_c = calibrated discharges

a, a_c, b, b_c = regression constants

n = number of observations

The restriction for the correlation coefficient ($R^2 > 0.50$) in both equations (5-4a) and (5-4b) has been made in order to prevent data analyses based on meaningless relations. If $R^2 < 0.50$, less then 50 % of the variation in discharge is explained by the stage discharge relation, which invalidates its use. If this is true ($R^2 < 0.50$) for the calibration measurements the conclusion must be that there is no proven

Example 5-1. Calculations float - pendulum relation

The float - pendulum relation of FB 03, Batts drain at Furgus will be treated here, following the procedures given above. The data used are taken from annex 2.1.2.

Step 1. Make a plot of $\bar{v}_f$ against $\bar{v}_p$, using the data of the calculation sheet of FB 03 (annex 2.1.2): see figure 5-1.

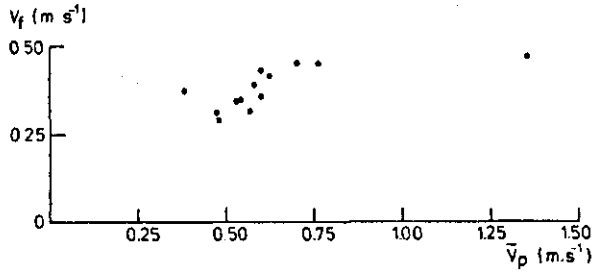


Fig. 5-1. FB 03, $\bar{v}_f$ - $\bar{v}_p$ plot

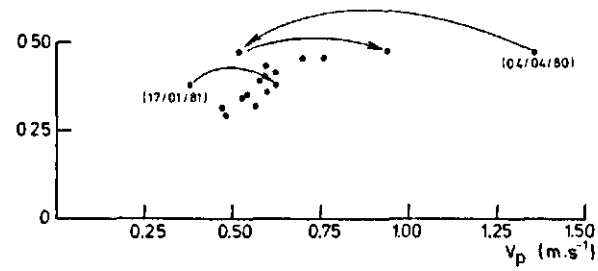


Fig. 5-2. $\bar{v}_f$ - $\bar{v}_p$ plot; correction of $\bar{v}_p$ data

Step 2. Identify unreliable data points: see fig. 5-2.

The data of 04/04/80 and 17/01/81 are found outside the data swarm in fig. 5-1. The measurement date for these two points is written near the points in the $\bar{v}_f$ - $\bar{v}_p$ plot (see fig. 5-2).
Recalculation of $\bar{v}_p$ for 04/04/80 (data from annex 1.1.3) gives $\bar{v}_p$ = 1.353. Conclusion: calculation correct.
Recalculation of $\bar{v}_f$ for 04/04/80 (data from annex 1.1.2) gives $\bar{v}_f$ = 0.470. Conclusion: calculation correct.
Recalculation of $\bar{v}_p$ for 04/04/80 (data from annex 1.1.3) using resistance body type K instead of the reported type M gives: $\bar{v}_p$ = 0.519. Replotting the point in the $\bar{v}_f$ - $\bar{v}_p$ plot (see fig. 5-2) results in a too low $\bar{v}_p$ value. Conclusion: most probably type K was not used.
Recalculation of $\bar{v}_p$ for 04/04/80 (data from annex 1.1.3) using resistance body type L instead of type K used in the previous calculation gives $\bar{v}_p$ = 0.942. Replotting the point in the $\bar{v}_f$ - $\bar{v}_p$ plot (see fig. 5-2) results in a too high $\bar{v}_p$ value. Conclusion: the measurement must be considered unreliable and has to be removed. The $\bar{v}_p$ value calculated and recorded on the calculation sheet is removed (see annex 3.1).
Recalculation of $\bar{v}_p$ for 17/01/81 (data from annex 1.1.3) gives $\bar{v}_p$ = 0.624. Conclusion: the calculations have not been performed correctly. Replace the reported value of $\bar{v}_p$ (= 0.382) by the correct value ($\bar{v}_p$ = 0.624). Record the correct point in the v_p - v_f plot (see fig. 5-2).

Step 3. Calculate the average float velocity and average pendulum velocity (on HP 97):
3.1. press DSP, 3 to have 3 significant digits behind the decimal point;
3.2. press f, CL REG to empty the registers used for the calculation of averages;
3.3. press f, P ↔ S to expose the protected registers;
3.4. press f, CL REG to empty the registers used for the calculation of averages;
3.5. press 0.409, Σ+ - store $\bar{v}_f$ of 18/04/80 (first date with reliable $\bar{v}_p$ and $\bar{v}_f$ measurements; (see annex 2.1.2);
3.6. repeat 3.5 with all $\bar{v}_f$ values for succeeding dates ; press $\bar{v}_f$, Σ+ excluding the measurement of 02/06/80 (no pendulum measurements);
3.7. after entering all $\bar{v}_f$ values (annex 2.1.2) press f, $\bar{x}$ and $\bar{v}_f$ = 0.371 is displayed;
3.8. repeat steps 3.2 - 3.7 for the $\bar{v}_p$ values of annex 2.1.2. and $\bar{v}_p$ = 0.589 is displayed.

Step 4. Calculate C_p (on HP 97):
press 0.371, ENTER ↑ - $\bar{v}_f$
press 0.589, ↑ - $\bar{v}_p$
display C_p = 0.630

Step 5. Draw the relation $\bar{v}_f$ = 0.630 $\bar{v}_p$ in the $\bar{v}_f$ - $\bar{v}_p$ plot (see fig. 5-3)

For drawing a straight line two points must be known:
- the point (0.0) is known
- the point (0.75, 0.472) can be calculated with the HP 97:
  press 0.75 ENTER ↑, 0.630, x displays 0.472.

Plot the point (0.75, 0.472) in the figure (see fig. 5-3) and draw a straight line through this point and through the origin.
Record C_p = 0.630 on the graph.

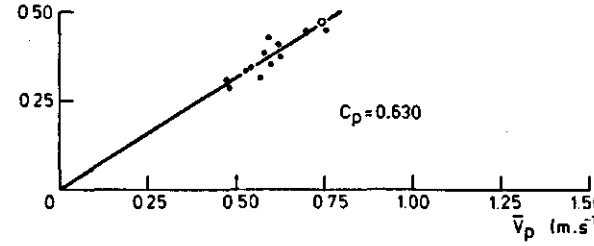


Fig. 5-3. Float - pendulum relation

Step 6. Check new pendulum constant against pendulum constant of the previous year.
Since 1980 has been the first observation year this cannot be done. Record C_p = 0.630 on the calculation sheet (see annex 3.1).

Step 7. Prepare a list of water depth, Q_f and Q_p
The water depth, D, is taken from annex 2.1.2.
The float discharge, Q_f, is calculated from $\bar{v}_f$ and A data given in annex 2.1.2: $Q_f = \bar{v}_f A$ ($c'_D = 1$)
The pendulum discharge, Q_p, is calculated from $\bar{v}_p$, C_p and A data given in annex 2.1.2: $Q_p = C_p \bar{v}_p A$ ($c'_D = 1$)
The following list results:

D	1.08	1.11	1.03	0.94	0.86	1.02	1.38	1.22	0.91	1.12	1.21	1.16
Q_f	3.26	3.69	3.32	2.76	2.17	2.50	3.40	2.69	2.08	2.54	3.23	3.25
Q_p	3.08	3.59	3.53	2.43	2.06	2.47	3.89	2.79	2.05	2.47	3.45	3.40

Step 8. Calculate R^2f and R^2p and chose the more reliable method, using HP 97 programme 'Curve fitting'.
8.1 Enter programme card 'Curve fitting' both sides;
8.2 press f, E for selection power curve fit;
8.3 press 1.08, ENTER , 3.26, A for storing the (D, Q_f) data pairs;
8.4 repeat step 8.3 until all (D, Q_f) data pairs have been entered;
8.5 press C for calculation. The calculator prints $R^2 = 0.44$
$a = 2.67$
$b = 0.91$
8.6 repeat steps 8.2 - 8.5 for the (D, Q_p) data pairs. The calculator prints $R^2 = 0.61$
$a = 2.60$
$b = 1.29$
The correlation coefficient for the pendulum measurements being higher ($R^2p = 0.61$ against $R^2f = 0.44$) the pendulum measurements are selected for the calculation of discharges.

Step 9. Not relevant in this case ($R^2p > R^2f$)

A summary of the data checking results based on the calculations of the float - pendulum relation for all open drainage measurement locations of annex 2 is given below:

Measurement point	Number of ($\bar{v}_f$, $\bar{v}_p$) data pairs: unreliable	deleted	corrected	C_p	R^2f	R^2p	More reliable method selected	Remarks
FB 03	2	1	1	0.630	0.44	0.61	pendulum	
FB 04	-	-	-	-	-	-	floats	no pendulum measurements
FB 05	-	-	-	-	-	-	-"-	-"-
EB 07	2	0	2	0.673	0.01	0.01	-"-	
EB 08	0	0	0	0.715	0.31	0.42	pendulum	
EH 11	2	0	2	0.949	0.15	0.31	-"-	
EH 13	-	-	-	-	-	-	-"-	no float measurements

relation between stage and discharge most probably due to disturbing backwater effects (the calibration measurements are performed with a high accuracy and reliability). If the correlation coefficient for the routine measurements is low ($R^2 < 0.50$) however, this may be due to the limited accuracy of the measurement methodology. This means that a relatively high amount of scatter (random error) is superimposed on the data used for establishing the relation. A method to suppress this scatter is the moving average analysis. To this purpose the (D, Q) data pairs have to be arranged according to increasing water depth. Next, for every D and Q value the average of n values is calculated using (n-1)/2 preceding and (n-1)/2 succeeding values. The moving average of 5 measurements M can than be formulated:

$$(\bar{M}_5)_i = \sum_{n=i-2}^{i+2} M_n \qquad \text{for } 2 < i < m-1 \qquad (5\text{-}5)$$

where: $\bar{M}_5$ = moving average for 5 values
i = hierarchy number (i^{th} measurement)
M_n = n^{th} measurement
m = number of measurement considered

Equation (5-5) cannot be applied for the first two measurements and for the last two measurements:

$$(\bar{M}_5)_i = M_i \qquad \text{for } i = 1 \text{ and } i = m \qquad (5\text{-}5a)$$

$$(\bar{M}_5)_i = (M_{i-1}+M_i+M_{i+1})/3 \qquad \text{for } i = 2 \text{ and } i = m-1 \qquad (5\text{-}5b)$$

When using the moving average date pairs ($\bar{D}_5$, $\bar{Q}_5$) for establishing relation (5-4a) a higher correlation coefficient may result and, if so, the relation will be more reliable. A standard HP 97 programme 'Moving average' is available for the calculation of $\bar{D}_5$ and $\bar{Q}_5$ (see example 5-2).
The correction coefficient for the systematic error in the routine measurements can be found by dividing equation (5-4b) by (5-4a):

$$c_D = \frac{a_c}{a} D^{b_c - b} \qquad \text{for } n \geq 3 \qquad (5\text{-}6)$$

where: c_D = correction coefficient for systematic error

a_c = discharge coefficient calibration relation (5-4b)

a = discharge coefficient routine relation (5-4a)

b_c = discharge exponent calibration relation (5-4b)

b = discharge exponent routine relation (5-4a)

n = number of calibration measurements

Generally the routine measurement discharges have been calculated using a correction factor for systematic error based on the results of the previous observation year (equation 4-12):

$$c'_{D_o} = a_o + b_o D \qquad (5\text{-}7)$$

where c'_D = correction factor used for calculation of discharges (equation 4-13 or 4-34)

a_o and b_o + regression coefficients

The total correction factor can be obtained by multiplying equations (5-6) and (5-7):

$$c_{Dt} = \frac{a_o a_c}{a} D^{b_c - b} + \frac{b_o a_c}{a} D^{b_c + 1 - b} \qquad (5\text{-}8)$$

Equation (5-8) generally can be approximated by a linear equation for the depth range of interest:

$$c'_D = a' + b' D \qquad (5\text{-}9)$$

where c'_D = new approximated correction coefficient for systematic error

a' and b' are regression coefficients

If less than 3 calibration measurements have been performed equation (5-4b) is not valid, and the correction coefficient for systematic error is given by the expression:

$$c_D = \bar{Q}_R(\bar{D}_c)/\bar{Q}_c \qquad \text{for } n < 3 \qquad (5\text{-}6a)$$

where: $\bar{Q}_R(\bar{D}_c)$ = discharge calculated with equation (5-4a) for water depth $\bar{D}_c$

$\bar{D}_c$ = average water depth for the calibration measurements (1 or 2) performed

$\bar{Q}_c$ = average of the calibrated discharges

In this case the correction factor used for the calculation of discharges must be a constant:

$$c'_{D_o} = a_o \qquad \text{for } n < 3) \qquad (5\text{-}7a)$$

and the total new correction factor is given by:

$$c'_D = a_o c_D \qquad \text{for } n < 3 \qquad (5\text{-}9a)$$

The complete procedure for the correction of discharges for systematic error at open drains is as follows (see also example 5-2):

1. Prepare a list of (D, Q_R) data pairs and (D, Q_c) data pairs. Take for Q_R either Q_f or Q_p measurements, depending on the best fit, but include the less reliable values for the observation dates for which the best fit method measurements have not been performed. Use for Q_p measurements the newly calculated c_p factor (see chapter 5.1.1.1).
2. Prepare a plot of (D, Q_R) measurements (see fig. 5-4) and identify and label unreliable (D, Q_R) data pairs that are obviously outside the swarm of data pairs. These points will be excluded from the analysis.
3. Exclude the unreliable (D, Q_R) data pairs and establish a power curve through the remaining (D, Q_R) data (eq. 5-4a) using the HP 97 standard programme 'Curve fitting'. If the correlation coefficient R^2 is greater than 0.50, step 4 - 6 should be skipped.
4. If the correlation coefficient $R^2 < 0.50$ only: prepare a list of (D, Q_R) data pairs according to increasing water depth D. (see example 5-2). If a certain water depth is occuring several times, these data pairs with the same water depth have to be listed according to increasing discharge.
5. Calculate the moving average with n=5 according to equation (5-5) using the standard HP 97 programme 'Moving Average' (see example 5-2).
6. Calculate the power curve (eq. 5-4a) using the moving averages $\bar{D}_5$ and $\bar{Q}_5$ calculated in step 5. If the correlation coefficient is still less than 0.50 one has to conclude that there is no stage-discharge relation.
7. Calculate the power curve (eq. 5-4b) using the (Q_c, D) data pairs from the calibration measurements if more than two calibrations have been performed. If the correlation coefficient of this relation is less than 0.50 one has to conclude that there is no stage - discharge relation. If only 1 or 2 calibrations have been performed this relation cannot be established.
8. Calculate the new c_D coefficient (equation 5-6 or 5-6a) and check the value of this coefficient for the depth range of interest. If $0.95 < c_D < 1.05$ for either the lowest depth or the highest depth measured during the observation year the old c'_D value can still be considered correct and the next steps of this procedure can be skipped.
9. If the calculated c_D coefficient is less than 0.95 or greater than 1.05 for the depth range of interest it has to be multiplied with the c'_D coefficient used for the calculation of discharges (equation 5-8).
10. Plot the c_{Dt} coefficient in a graph (see fig. 5-5) for the depth range of interest and use 5 to 10 (D, c_{Dt}) data pairs for the linear approximation (5-9) by using the linear regression option (press

Example 5-2. Calculations correction for systematic error

The correction for systematic error in discharge determination of EB 07, Bahr Bagar drain at 'Kubri Saud' will be treated here, following the procedures given above. The data used are taken from annex 2.4.2. and from example 5-1 and the results are given in annex 3.

Step 1. Prepare a list of (D, Q) data pairs (see table 5-1); data from annex 2.4.2.

Step 2. Prepare a plot of D, Q_R data pairs and identify unreliable points. The point (2.81, 43.78) is found outside the data swarm in fig. 5-4 (measurement of 20/04/80)

	D	Q_R *	D ***	Q_R	$\bar{D}_5$	$\bar{Q}_{R5}$
	3.27	44.48	2.74	30.21	2.74	30.21
	3.04	36.20	2.81	32.65	2.80	33.41
	2.92	29.63	2.84	37.37	2.83	33.28
	2.74	30.21	2.86	39.38	2.85	35.19
	3.05	42.14	2.88	26.80	2.87	35.38
	2.96	41.20	2.88	39.74	2.89	33.35
	2.91	27.23	2.90	33.61	2.90	33.40
	2.84	37.37	2.91	27.23	2.91	35.21
	2.81	43.78 +	2.92	39.63	2.93	35.50
	2.81	32.65	2.95	35.84	2.95	34.87
	2.88	26.80	2.96	41.20	2.98	36.66
	2.90	33.61	3.03	30.43	3.00	37.54
	2.86	39.38	3.04	36.20	3.02	38.80
	2.88	39.74	3.04	44.03	3.05	36.59
	2.95	35.84	3.05	42.14	3.06	38.20
	3.08	38.46	3.07	30.17	3.07	36.75
	3.22	36.62	3.08	38.46	3.08	34.22
	3.18	39.76	3.09	28.95	3.10	33.75
	3.09	28.95	3.10	31.39	3.13	35.04
	3.04	44.03	3.18	39.76	3.17	36.24
	3.10	31.39	3.22	36.62	3.22	38.46
	3.07	30.17	3.27	44.48	3.27	40.38
	3.32	40.05	3.32	40.05	3.32	40.05
	3.03	30.43				
C**	3.18	37.24				
C	3.24	33.46				
C	3.07	28.47				

* = the Q_f has been taken because $R^2f = R^2p = 0.01$

** = this are calibration measurements

*** = arranged according to increasing water depth

\+ = this point was found unreliable in fig. 5-4 for outside data swarm) and has therefore not been included in the next columns

Table 5-1. EB 07 List of (D,Q) data pairs and moving averages

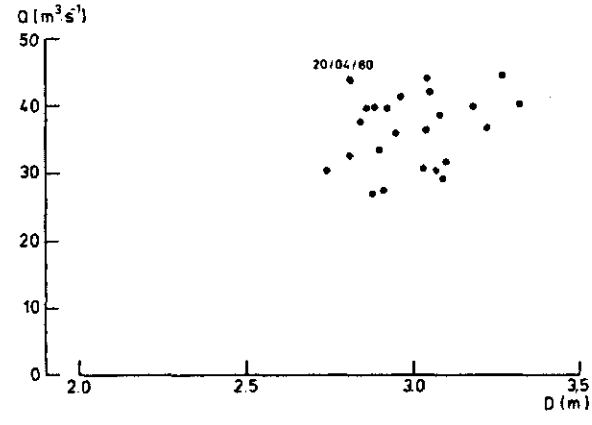


Fig. 5-4. EB 07, D-Q_R plot

Step 3. Power curve fit of remaining data: $Q = 10.92\ D^{1.08}$ $R^2 = 0.13$
The correlation coefficient is less than 0.50.

Step 4. Prepare a list of (D, Q_R) data pairs according to increasing water depth; see column 3 and 4 of table 5-1.

Step 5. Calculate moving average of D and Q: see column 5 and 6 of table 5-1.
The following steps have to be taken for calculating $\bar{D}_5$:

- 2.74 $(\bar{D}_5)_1 = D_1$ (equation 5-5a)
- enter programme 'moving average'
- 5 press f A; gives the number of data used for the moving average calculation
- 2.74 press A; D_1
- 2.81 press A; D_2
- 2.84 press A; D_3
- press E, displays 2.80; $(\bar{D}_5)_2$, using 3 D values (equation 5-5b)
- 2.86 press A; D_4
- 2.88 press A, dispalys 2.83; $(\bar{D}_5)_3$
- 2.88 press A; displays 2.85; $(\bar{D}_5)_4$

etc.

After entering all D values two $\bar{D}_5$ values for i=m and i=m-1 still have to be calculated:
$(D_5)_m = D_m = 3.32$
$(D_5)_{m-1} = (D_{m-2} + D_{m-1} + D_m)/3 = (3.22 + 3.27 + 3.32)/3 = 3.27$
The moving averages of discharge are calculated in a similar manner.

Step 6. Power curve fit of moving average data: $Q = 11.37\ D^{1.04}$ $R^2 = 0.59$

Step 7. Power curve fit of calibration measurement data: $Q_c = 0.52\ D^{3.60}$ $R^2 = 0.53$

Step 8. Calculate the new c_D coefficient:
a = 0.52/11.37 = 0.0457 and b = 3.60 - 1.04 = 2.56 (equation 5-6)
For D = 2.7 m $c_D = 0.0457\ (2.7)^{2.56} = 0.581$
The correction factor is smaller than 0.95 for one point in the depth range of interest and thus has to be applied.

Step 9. The old c'_D coefficient was ussumed 1, since 1980 was the first year of observation.
Therefore:

$$c_{Dt} = 0.0457\ D^{2.56} \quad \text{(equation 5-8)}$$

Step 10. Plot the c_{Dt} coefficient (see figure 5-5).
The depth range of interest is for D values between 2.7 and 3.4 m.
Using the expression for c_{Dt} the following (D, c_{Dt}) pairs can be calculated:

D	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4
c_{Dt}	0.581	0.638	0.698	0.761	0.828	0.898	0.971	1.048

Linear regression: $c'_D = -1.23 + 0.667\ D$ $R^2 = 0.998$

Step 11. Record c'_D on calculation sheet (annex 3.4)
Recalculate all discharges using the new c'_D coefficient

This can easily be done on the HP 97 by the following activities:

D press E; c'_D
$\underline{A}$ x ; $c'_D \times A$
v_f x ; $Q = c'_D \times \bar{v}_f \times A$
The results are given in annex 3.4

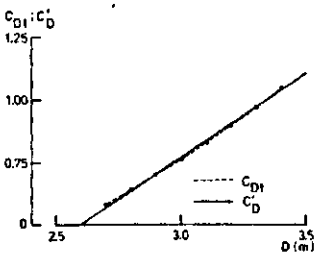


Fig. 5-5. EB 07, correction factor c'_D for systematic error

A summary of the data checking results based on the calculations of the correction for systematic error for all open drainage measurement locations of annex 2 is given below:

Measurement point	Number of unreliable points	Correlation coefficient R^2			c'_D			Remarks
		Q_R data	$(\bar{Q}_R)_5$ data	Q_c data	a	b	R^2	
FB 03	0	0.89	-	-	0.879	-	-	2 calibrations
FB 04	0	*	-	-	-	-	-	1 calibration **
FB 05	1	0.94	-	0.93	1.56	-0.472	0.95	
EB 07	1	0.13	0.59	0.53	-1.23	0.667	0.998	
EB 08	1	0.39	0.84	0.81	-0.93	0.598	0.997	
EH 11	1	0.48	0.70	-	0.437	-	-	2 calibrations
EH 13 ***	-	-	-	-	-	-	-	no Q - D relation

* $R^2 = 0.95$ for the period until august 1980)
$R^2 = 0.99$ for the period after august 1980) different Q - D relations have been found for both periods

** The calibration measurement is outside the range of normal depths for the routine measurements and the calculation of a correction factor is therefore not justified

*** For the Bahr Hadus drain at 'Outfall' a different approach has been used.
In annex 2.8.1 the discharge data of 1979, 1981 and 1982 have been included, because only a limited number of measurements have been made during 1980.
Looking at the water depth observations it appears that the water depth at reference point is rather constant (2.3 meter) except during the winter closure period (februari: D ≃ 2.2 meter). Only for one date (06/08/1980) both a calibration measurement and pendulum measurements have been performed. Assuming the wetted cross-section to be constant, a direct relation between the average pendulum velocity and the discharge may be expected. Based on the measurement of 06/08/1980 this relation is : $Q = 247\ \bar{v}_p$.
Using this relation the discharges for the other dates for which pendulum meter measurements have been performed have been calculated (see annex 3.7).
For the data checking procedures it will be necessary to have discharge data and water quality data for the same observation dates. Therefore, in annex 3.7 the discharges calculated from the pendulum measurements and calibration measurements have been linearly interpolated to the dates of waterquality observations. The procedures to be followed for linear interpolation will be treated in chapter 6.

f B) of the standard HP 97 programme 'Curve fitting'.

11. Record the c'_D coefficient on the calculation sheet and recalculate all discharges using the new c_p and c'_D correction factors. Record these discharges on the calculation sheets, replacing the original figures (see annex 3).

5.1.2. Stage - discharge relation

Considering the stage - discharge relation of eq. (5-4) based on the routine measurements and on the calibration measurements, unreliable (D, Q_R) data pairs can be identified by considering the fractional difference between the discharge estimated with equation (5-4) for the measured water depth and the measured discharge:

$$\Delta Q = \frac{\tilde{Q} - Q}{Q} \qquad (5\text{-}10)$$

where: ΔQ = fractional deviation in discharge

$\tilde{Q}$ = estimated discharge with (equation 5-4)

Q = measured discharge

The data point in question can be considered unreliable if $|\Delta Q| > 0.20$

The procedure for the detection of unreliable points using the stage - discharge relation is as follows (see also example 5-3):

1. Prepare a list of the depths measured and the discharges calculated after correction for the systematic error. Include the calibration points at the bottom of this list. Include also the date of observation.
2. Prepare a plot of all points on the list (see fig. 5-6). Plot discharge against water depth and identify (D, Q) data pairs that are outside the normal range. Mark these data points on the plot and on the list.
3. Establish the stage - discharge relation through the remaining (D, Q) data pairs including the calibration measurements using the HP 97 standard 'Curve fitting' programme with the power curve option (press f E). Draw the relation in the D-Q plot (see fig. 5-7).
4. Check the reference datum for water depth. If the calculated stage - discharge relation is obviously much flatter or much steeper than the plotted (D,Q) data the reference datum for water depth has to be

Example 5-3. Identification unreliable discharge measurements using the stage - discharge relation

The detection of unreliable measurements of EB 07, Bahr Baqar drain at 'Kubri Saud' will be treated here according to the procedures given above. The data used are taken from annex 3.4 and examples 5-1 and 5-2.

Step 1. Prepare a list of observations, corrected for systematic error. See table 5-2.

Step 2. Prepare a plot of these (D,Q_R) and(D,Q_c) data pairs. See fig. 5-6. Identify and mark (number) unreliable data pairs that are far outside the range of normal data scatter. Result: no points (fig. 5-6).

Date	Depth	Q_R	$\frac{\tilde{Q} - Q_R}{Q_R}$	Point identification
20/12/79	3.27	42.26	-0.13	
06/01/80	3.04	28.82	0.00	
27/01/80	2.92	28.40	-0.12	
10/02/80	2.74	18.00	0.13	
25/02/80	3.05	33.81	-0.14	
09/03/80	2.96	30.59	-0.14	
23/02/80	2.91	19.33	0.28	1
13/04/80	2.84	24.79	-0.08	
20/04/80	2.81	28.12	-0.22	2
04/05/80	2.81	20.98	0.05	
26/05/80	2.88	18.47	0.30	3
03/06/80	2.90	23.60	0.04	
15/06/80	2.86	26.60	-0.12	
29/06/80	2.88	27.38	-0.12	
16/07/80	2.95	26.35	-0.01	
31/07/80	3.08	31.67	-0.05	
18/08/80	-	-		
22/09/80	3.22	33.52	0.04	
04/10/80	3.18	35.40	-0.06	
27/10/80	3.09	24.05	0.26	4
11/11/80	3.04	35.07	-0.18	
24/11/80	3.10	26.23	0.17	
07/12/80	3.07	24.66	0.20	5
25/12/80	3.32	39.40	-0.02	
07/01/80	3.03	24.02	0.18	
CAL	3.18	37.24		
CAL	3.24	33.46		
CAL	3.07	28.47		

Table 5-2. EB 07, list of(D,Q_R) data pairs and identification unreliable measurements

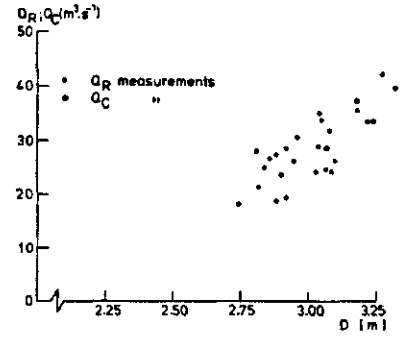


Fig. 5-6. EB 07, D-Q_R plot after correction for systematic error

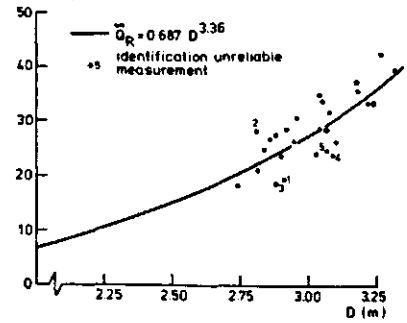


Fig. 5-7. EB 07, stage - discharge relation and unreliable data points

Step 3. Establish the stage - discharge relation using the HP 97 programme power curve fit:

$Q_R = 0.687\ D^{3.36}$ $R^2 = 0.59$

Draw the relation in the D - Q_R plot of fig. 5-6 (see fig. 5-7). Points of the relation can be calculated with the HP 97 by performing the following steps:

D press E displays $\tilde{Q}_R$

In this case (see fig. 5-7)
enter 2 press E displays 7.04
enter 2.25 press E displays 10.46
enter 2.5 press E displays 14.90
etc.
Using a french curve the relation is drafted, through these calculated points (fig. 5-7).

Step 4. Check the reference datum for water depth. Result: no problem (see fig. 5-7).

Step 5. No relevant in this case.

Step 6. Calculate the fractional discharge difference (see teble 5-2).
Starting with the measurement of 20/12/79:
enter D = 3.27; press E displays $\tilde{Q}_R$ = 36.71; enter Q_R = 42.26; press - displays - 5.55; enter 42.26; press + displays - 0.13
enter 3.04; press E displays 28.74; enter 28.82; press - displays - 0.08; enter 28.82; press + displays -2.8×10^{-3}
enter 2.92; press E displays 25.10; enter 28.40; press - displays - 3.30; enter 28.40; press + displays - 0.12
etc.

Step 7. Label the unreliable points ($\frac{\tilde{Q}_R - Q_R}{Q_R} \geq 0.20$) in the list and in the plot (see table 5-2 and fig. 5-7)
Result: the discharge measurements of 23/03/80, (point 1); 20/04/80 (point 2); 26/05/80 (point 3); 27/10/80 (point 4); and 07/12/80 (point 5) are considered unreliable.

A summary of the identification of unreliable discharge measurements using the stage - discharge relation for all open drainage measurement locations of annex 3 is given below

Measurement point	Number of unreliable points*	Reference datum water depth (m)	Discharge relation a	b	R^2	Number of unreliable points Q-D relation **	Remarks
FB 03	-	-	2.13	1.63	0.91	5	
FB 04	-	+0.20	6.97	2.26	0.95	4	until august 1980
-"-		+0.20	3.28	1.94	0.99	-	after august 1980
FB 05	1	+0.15	5.27	1.44	0.91	6	
EB 07	-	-	0.687	3.36	0.59	5	
EB 08	1	-	0.328	4.14	0.77	3	
EH 11	1	-	0.0456	4.94	0.53	10	
EH 13	-	-	-	-	-	-	no stage - discharge relation

* unreliable points that are outside the normal range of data scatter
** unreliable points based on the fractional discharge difference

adjusted. This is the case for the measurement points FB 04 and FB 05. In both cases a re-examination of the measured downstream cross-section shows that the reference point does not give the maximum depth in the downstream cross-section and adjustments of respectively 0.20 and 0.15 m are necessary.

5. After adjustment of the reference water depth repeat step 3. The correlation coefficient should be higher now.

6. Calculate the fractional discharge difference:
   - enter D in HP 97 (measured water depth)
   - press E (calculates $\tilde{Q}$)
   - enter Q, press — (calculates $(\tilde{Q} - Q)$
   - enter Q, press + (calculates $(\tilde{Q} - Q)/Q$

   Record ΔQ on the list (see example 5.3).
7. Label the unreliable points on the list and in the plot with drafted relation (see fig. 5-7) by numbering them (see example 5-3)

5.1.3. Discharge double mass analysis

The discharge of two nearby located catchment area's can be expected to be related, based on the assumption that the irrigation regime and practices and the cropping patterns will show similarity. If the discharge from these catchment area's is by means of open drains that have a stage - discharge relation also the water depths will be related to each other.

By curve fitting the measured quantities of both measuring points (according to the sequence given in annex 4) can be used to determine the empirical selection (power curve) between both:

$$Q_j = a_q Q_i^{b_q} \qquad (5\text{-}11a)$$

and

$$D_j = a_d D_i^{b_d} \qquad (5\text{-}11b)$$

where: Q_j and D_j are the measured discharge and water depth of measurement point j respectively

Q_i and D_i are the measured discharge and water depth of measurement point i respectively

a_q and b_q are the regression constants of the discharge double mass relation (5-11a)

a_d and b_d are the regression constants of the waterdepth double mass relation (5-11b)

Using the fractional differences of the quantities calculated by equation (5-11) and the measured quantities and comparing this difference with a certain criterium unreliable measurements can be identified:

$$|\Delta Q| = \frac{\tilde{Q}_j - Q_j}{Q_j} > C_1 \qquad (5\text{-}12a)$$

$$|\Delta D| = \frac{\tilde{D}_j - D_j}{D_j} > C_2 \qquad (5\text{-}12b)$$

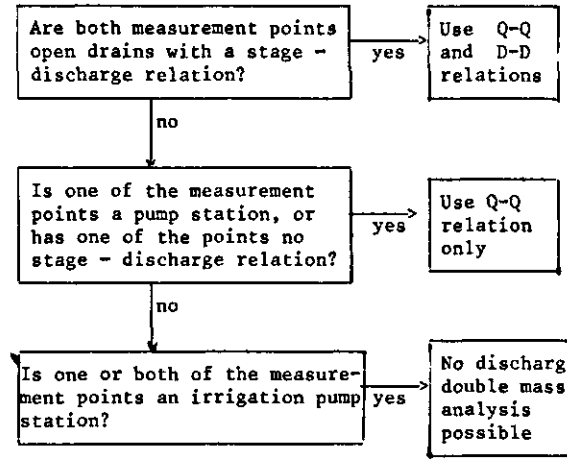
where: ΔQ and ΔD are the fractional differences

$\tilde{Q}_j$ and $\tilde{D}_j$ are the discharge and water depth calculated with equation (5-11)

C_1 and C_2 are the criteria according to which measurements are considered unreliable

The normal value for C_1 and C_2 is 0.20. If the relation between both quantities is weak (low R^2 and great scatter of the data) it may be necessary to increase C_1 and/or C_2 to 0.30 or 0.40. On the other hand, if the relation is very strong, C_1 and C_2 may be decreased to 0.10.

The application of equations (5-11) and (5-12) is based on the following decision structure:



The procedure for detection of unreliable discharge measurements using the double mass analysis relations is as follows (see also example 5-4):

1. Prepare a list including the date of observation, the measured water depth, and the calculated discharge of the measurement points that have to be compared (see annex 4). Include the identification number based on the stage - discharge relation (see table 5-3).
2. Prepare a plot of water depth against water depth and discharge against discharge. See fig. 5-8 and fig. 5-9. Identify unreliable (D,D) and (Q,Q) data pairs, that are far outside the cluster of points un the figures.
3. Establish the 'best fit' power curve through the remaining data of table 5-3, both for water depth if applicable and for discharge. Calculate the fractional depth and discharge differences (eq. 5-12) and record the results in the list (see table 5-3.
4. Label the additional unreliable points according to equation (5-12) using the criteria of 0.20. If no data points are identified as unreliable using this criterion , try C = 0.10. On the other hand, if too much data points are considered unreliable (more than 10) try C = 0.30 or C = 0.40 (see example 5-4). Label the identified unreliable points by numbering, both on the list (see table 5-3) and on the figures 5-8 and 5-9.

Once the discharge measurements that have to be considered for possible correction of either the water depth or the velocity have been identified preliminary corrections of both parameters can be applied. In this stage of data consistency analysis the corrections are preliminary; in chapter 5.3 the procedures for checking the preliminary corrections on consistency using the salt double mass analysis will be treated and the decision whether the preli-

Example 5-4. Identification unreliable discharge measurements using the double mass analysis relations

The data used for this example are from EB 07, Bahr Baqar drain at 'Kubri Saud' and EB 08, Bahr Baqar drain at 'Kubri Bahr Baqar' and are taken from annex 3.4 and 3.5.

Step 1. Prepare a list of discharge observation of both measurement points. See table 5-3.

Date	D_7	Q - D relation	D_8	Ident. Q - D relation	$\frac{\tilde{D}_8 - D_8}{D_8}$	Ident. D - D relation	Q_7	Ident. Q - D relation	Q_8	Ident. Q - D relation	$\frac{\tilde{Q}_8 - Q_8}{Q_8}$	Ident. Q - Q relation
20/12/79	3.27		3.16		-0.02		42.26		41.11		-0.10	
6/01/80	3.04		2.96		-0.02		28.82		33.71		-0.20	12
27/01/80	2.92		2.85		-0.02		28.40		27.03		-0.01	
10/02/80	2.74		2.73		-0.03		18.00		22.23		-0.18	
25/02/80	3.05		2.94		-0.01		33.81		-		-	
9/03/80	2.96		2.87		-0.01		30.59		24.46		0.16	
23/03/80	2.91	1	2.93		-0.05		19.33	1	26.02		-0.26	13
13/04/80	2.84		2.82		-0.03		24.79		21.02		0.13	
20/04/80	2.81	2	2.69		0.01		28.12	2	21.74		0.22	14
4/05/80	2.81		2.45		0.11	10	20.98		13.84		0.49	15
26/05/80	2.88	3	2.81		-0.01		18.47	3	21.66		-0.14	
3/06/80	2.90		2.83		-0.02		23.60		21.96		0.04	
15/06/80	2.86		2.77		-0.01		26.60		24.25		0.04	
29/06/80	2.88		2.72		0.02		27.38		21.68		0.19	
16/07/80	2.95		2.74		0.03		26.35		24.45		0.02	
31/07/80	3.08		2.83		0.04		31.67		30.17		-0.03	
18/08/80	-		2.88		-		-		27.20		-	
22/09/80	3.22		3.09		-0.01		33.52		38.28		-0.20	16
4/10/80	3.18		3.05	6	-0.01		35.40		41.62	6	-0.23	17
27/10/80	3.09	4	2.71	7	0.09		24.05	4	15.71	7	0.48	18
11/11/80	3.04		3.92	8	-0.26	11	35.07		64.48	8	-0.51	19
24/11/80	3.10		2.97		-0.01		26.23		27.04		-0.08	
7/12/80	3.07	5	2.92	9	0		24.66	5	21.48	9	0.10	
25/12/80	3.32		3.05		0.02		39.40		29.82		0.18	
7/01/81	3.03		3.03		-0.05		24.02		28.50		-0.19	

Table 5-3. EB 07 and EB 08, list of (D, Q_R) data pairs and identification unreliable measurements

Step 2. Prepare a D-D and Q-Q plot and identify unreliable data pairs. See fig. 5-8 and fig. 5-9.

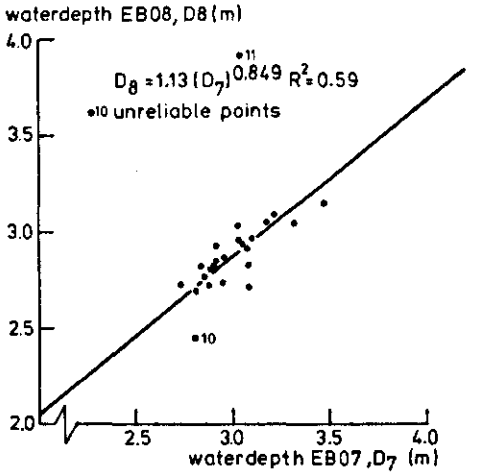


Fig. 5-8. EB 07 and EB 08, stage - stage relation and unreliable data points

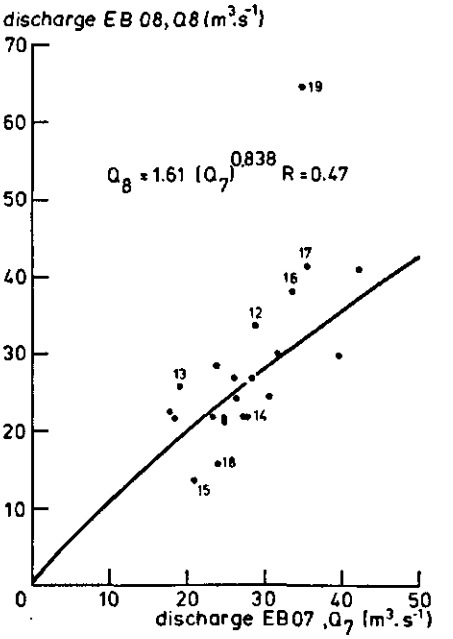


Fig. 5-9. EB 07 and EB 08, discharge - discharge relation and unreliable data points

Point 11 in fig. 5-8 and point 19 in fig. 5-9 are identified far outside the normal range of data scatter.

Step 3. Power curve water depth: $D_8 = 1.13\ (D_7)^{0.849}$ $R^2 = 0.59$
Calculate fractional depth difference (table 5-3)
Power curve discharge: $Q_8 = 1.61\ (Q_7)^{0.838}$ $R^2 = 0.47$
Calculate fractional discharge difference (table 5-3)

Step 4. Label unreliable data points.
Taking $C_1 = 0.20$ for the $D_8 - D_7$ relation only one point (11) is identified.
Therefore take $C_1 = 0.10$; 2 unreliable depth measurements. See table 5-3 and fig. 5-8.
Taking $C_1 = 0.20$ for the $Q_8 - Q_7$ relation 8 unreliable discharge measurements are identified. See table 5-3 and fig. 5-9.

A summary of the identification of unreliable discharge measurements using the stage - discharge and the double mass relations is given below.

Measurement points (annex 4)	Stage double mass relation				Discharge double mass				Number of unreliable discharge measurements				
									Q - D relation		D-D relation	Q-Q relation	Total*
	a	b	R^2	C_1	a	b	R^2	C_2	1st point	2nd point			
FB03 - FB04***	0.514**	1.28**	0.91	0.20	0.462	1.78	0.86	0.30	5	4	1	8	12
FB03 - FB05	1.01	1.08	0.87	0.20	2.76	1.04	0.94	0.20	5	6	3	5	12
EB07 - EB08	1.13	0.849	0.59	0.10	1.61	0.838	0.47	0.20	5	4	1	7	10
EH11 - EH13+	-	-	-	-	6.58	0.550	0.22	0.30	11	-	-	6	13
MG09 - MG10+	-	-	-	-	0.756	1.08	0.90	0.10	-	-	-	2	2
WE10 - WE11+	-	-	-	-	2.30	0.664	0.57	0.40	-	-	-	7	7

* In this column the total number of discharge measurements that have to be considered for correction is given. If the measurements of this date have been identified as unreliable in more than one of the 4 relations considered it is counted only once in this column.

** The stage double mass relation given is that of before august 1980
For the period after august 1980 $a = 0.985$, $b = 0.493$ and $R^2 = 0.67$ has been found

*** According to Annex 4 the sum of FB04 has to be compared with FB05. Because of the change in the stage - discharge relation since august 1980 for the measurement point FB04 the data of FB03 have been related directly with the data of FB05.

\+ No stage double mass curves have been established because for EH 13 no stage - discharge curve can be found and MG 09, MG 10, WE 10 and WE 11 are pump stations.

minary corrections have to be maintained will be discussed.

The application of preliminary corrections can be facilitated by using a qualitative matrix indicating the deviations of the unreliable discharge measurement from the empirical stage - discharge and double mass analysis curves. The structure of the matrix is as follows:

Relation	Depth	Discharge
Stage - discharge	.	.
Double mass	.	.

The elements of the matrix can be filled with positive signs (+) if the measurement is higher than according to the empirical relation, a negative sign (-) if the measurement is lower than according to the empirical relation. The element can be left open or filled with a zero (0) if the measurement is exactly on the empirical relation (or very close to it).

The first row of the matrix is filled based on the Q-D plot and the stage - discharge relation. If the measurement point in question is on the right side of the regression line an (+) is filled in under 'Depth' and an (-) under 'Discharge' . If the point is above this line an (-) must be filled in below 'Depth' and an (+) below 'Discharge'.

The second row is filled based on the double mass plots (D-D and Q-Q) and the double mass relations. In the first column, second row, an (+) is indicated of the (D,D) data point is located on the same side of the D-D relation as the axis of the measurement point in question. An (-) has to be indicated if the data point is on the other side of the D-D relation. In the second column, second row, an (+) is indicated if the (Q,Q) data point is on the same side of the Q-Q double mass relation as the axis of the measurement point in question. An (-) has to be indicated if the data point is on the other side. Based on the configuration of the qualitative matrix it can be decided where (which measurement point) the correction has to be made and which measurement (depth or velocity) has to be corrected:

- correction of depth for the following configurations:

	D	Q	D	Q
Q - D	+	-	-	+
D - D; Q - Q	+	+	-	-

- correction of velocity for the following configurations:

	D	Q	D	Q	D	Q	D	Q	D	Q	D	Q	D	Q	D	Q
Q-D	-	+	-	+	-	+	-	+	+	-	+	-	+	-	+	-
D-D;Q-Q	+	+	0	+	-	+	0	+	-	-	0	-	+	-	0	-

- no correction is warranted for all other matrix configurations.

The use of the matrix is confined to the comparison of two measurement points that are both open drains with a stage - discharge relation. If one of the points has no stage - discharge relation an incomplete matrix can be made with a blank position in the first column, second row: M (1,2). In this case the correction of the measured water depth is not an option, unless when this is obvious from the Q-D plot i.e. when the depth of the (Q,D) point in question is far outside the range of normal depths measured during the observation year. If both measurement points are open drains without stage - discharge relation or pump stations no matrix can be constructed at all and corrections on discharges cannot be applied without additional evidence.

Once it has been decided which parameter, depth on velocity, needs to be (preliminary) corrected the corrected value can be estimated as:

- correction of depth:
  the average of the D value derived from the stage - discharge relation and the D value derived from the D-D double mass relation. Next the discharge has to be recalculated with the corrected D value according to the procedures described in chapter 4.1.1.2. for the float measurement or in chapter 4.1.1.3 for the pendulum measurements
- correction of discharge:
  the average of the Q value derived from the stage - discharge relation and the Q value derived from the Q-Q double mass relation.

In all cases, before preliminary corrections are to be applied the field forms should be inspected on possible mis-interpretations of field data and the subsequent data processing (chapter 4) checked.

The complete procedure for the preliminary discharge data correction is as follows (see also example 5-5).

1. Collect the pertinent information necessary for the preliminary correction of discharge measurement of the measurement points that have to be compared according to the sequential list given in annex 4. This includes the list of (D, Q_R) data pairs with the identification of unreliable measurements and the stage - discharge and double mass analysis relations found. For measurement points that have already been involved in double mass analysis data checking before, according to the sequential list of measurement points in annex 4, the (preliminary) corrected data have to be used. This rule has not been obeyed in the examples given in the annexes.
2. Construct the qualitative matrices (if appropriate) for the discharge measurements found unreliable in one or more of the relations collected under step 1. If one of the measurement points has no stage - discharge relation, or is a pump station the element M(1,2) of the matrix can be left open (filled with a blank).
   Construct the matrices for both measurement points that have to be compared.
3. On basis of the matrix configuration for both measurement points it has to be decided which element (depth or discharge) of which measurement point has to be corrected. See example 5-5.
   If both measurement points are pump stations no matrix can be constructed and the decision which point needs to be corrected may be based on the historical discharge record.
4. Check the field measurement forms of the measurement point and date of measurement identified as unreliable and repeat the ensuing calculations for possible mis-interprelation of the field observations and mistakes in the data elaborations. For pump stations the original data records have to be inspected on possible mis calculations.
   Correct any differences found on the calculation sheets, replacing the original values.
5. If no deviations have been found in step 4 a preliminary correction has to be applied:
   - Correction of the depth
     + calculate the depth from the Q-D relation using the calculated discharge as input:
       $D_Q = (a^{-1}Q)^{1/b}$
     + calculate the depth from the D-D relation using the measured depth of the 'reliable' point as input:
       $D_D = a\,D_r^b$ or $D_D = (a^{-1}\,D_r)^{1/b}$
     + calculate the average of both:
       $D_c = (D_Q + D_D)\,/2$
     + check the new D_c value on the D-D relation. If the data pair (D_c, D_r) is still far away from the relation found replace D_c by D_D:
       $D_c = D_D$

Example 5-5. Preliminary discharge data correction

The data of EB 07, Bahr Baqar drain at 'Kubri Saud' and EB 08, Dahr Baqar drain at 'Kubri Bahr Baqar' have been used in this example for illustration (Annex 3.4 and 3.5).

Step 1. Collect pertinent information. See figs 5-7, 5-8, 5-9, 5-10 and table 5-3.

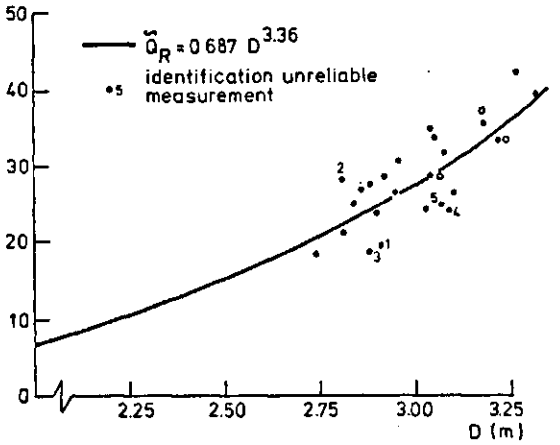


Fig. 5-7. EB 07, stage - discharge relation and unreliable data points

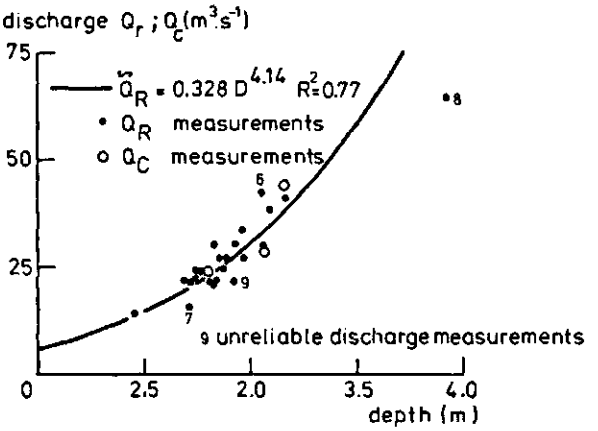


Fig. 5-10. EB 08, stage - discharge relation and unreliable data points

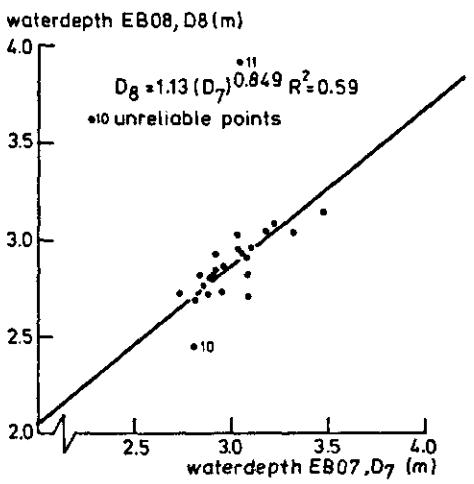


Fig. 5-8. EB 07 and EB 08 stage - stage relation and unreliable data points

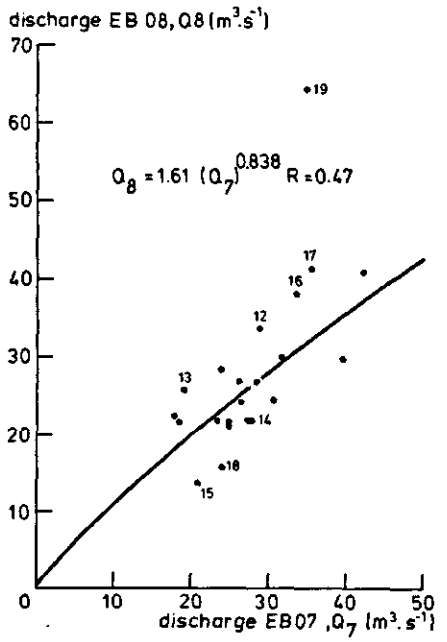


Fig. 5-9. EB 07 and EB 08 discharge - discharge relation and unreliable data points

Date	D_7	Ident. Q - D relation	D_8	Ident. Q - D relation	$\frac{\tilde{D}_8 - D_8}{D_8}$	Ident. D - D relation	Q_7	Ident. Q - D relation	Q_8	Ident. Q - D relation	$\frac{\tilde{Q}_8 - Q_8}{Q_8}$	Ident. Q - Q relation
20/12/79	3.27		3.16		-0.02		42.26		41.11		-0.10	
6/01/80	3.04		2.96		-0.02		28.82		33.71		-0.20	12
27/01/80	2.92		2.85		-0.02		28.40		27.03		-0.01	
10/02/80	2.74		2.73		-0.03		18.00		22.23		-0.18	
25/02/80	3.05		2.94		-0.01		33.81		-		-	
9/03/80	2.96		2.87		-0.01		30.59		24.46		0.16	
23/03/80	2.91	1	2.93		-0.05		19.33	1	26.02		-0.26	13
13/04/80	2.84		2.82		-0.03		24.79		21.02		0.13	
20/04/80	2.81	2	2.69		0.01		28.12	2	21.74		0.22	14
4/05/80	2.81		2.45		0.11	10	20.98		13.84		0.49	15
26/05/80	2.88	3	2.81		-0.01		18.47	3	21.66		-0.14	
3/06/80	2.90		2.83		-0.02		23.60		21.96		0.04	
15/06/80	2.86		2.77		-0.01		26.60		24.25		0.04	
29/06/80	2.88		2.72		0.02		27.38		21.68		0.19	
16/07/80	2.95		2.74		0.03		26.35		24.45		0.02	
31/07/80	3.08		2.83		0.04		31.67		30.17		-0.03	
18/08/80	-		2.88		-		-		27.20		-	
22/09/80	3.22		3.09		-0.01		33.52		38.28		-0.20	16
4/10/80	3.18		3.05	6	-0.01		35.40		41.62	6	-0.23	17
27/10/80	3.09	4	2.71	7	0.09		24.05	4	15.71	7	0.48	18
11/11/80	3.04		3.92	8	-0.26	11	35.07		64.48	8	-0.51	19
24/11/80	3.10		2.97		-0.01		26.23		27.04		-0.08	
7/12/80	3.07	5	2.92	9	0		24.66	5	21.48	9	0.10	
25/12/80	3.32		3.05		0.02		39.40		29.82		0.18	
7/01/81	3.03		3.03		-0.05		24.02		28.50		-0.19	

Table 5-3. EB 07 and EB 08, list of (D, Q_R) data pairs and identification unreliable measurements

Steps 2 - 6. Correct unreliable points:

Points 12 has been detected in the Q-Q relation of 6/10/80
Checking Q-D of EB 07 (fig. 5-7) D = 3.04; Q = 28.82 (table 5-3) indicates that the point is exactly on the relation found empirical.
Checking D-D of the data point 12 (fig. 5-8) D_7 = 3.04; D_8 = 2.96 (table 5-3) indicates that the point is only very slightly deviating from the empirical relation found.
Checking Q-Q of the data point 12 (fig. 5-9) indicates that either Q_7 is too low (-) or Q_8 is too high(+).
Checking Q-D of EB 08 (fig. 5-10) D = 2.96; Q = 33.71 (table 5-3) indicates thateither D_8 is too low (-) or Q_8 is too high (+).
The matrix for EB 07 is therefore: 0 0 / 0 - and for EB 08: - + / 0 +
For EB 07 no correction is warranted; for EB 08 the velocity is liable to correction (2nd configuration of matrices for velocity correction; see text).
A check of the field measurements (Annex 1.5.2) and subsequent calculations gives the same result: Q = 33.71.
Correction of discharge of EB 08 according to the Q-D relation gives: $Q_8 = 0.328\ (2.96)^{4.14} = 29.31$ (fig. 5-10).
Correction of discharge of EB 08 according to the Q-Q relation gives: $Q_8 = 1.61\ (28.82)^{0.838} = 26.92$ (fig. 5-9).
Average: (29.31 + 26.92)/2 = 28.11.
On the calculation sheet (annex 5.5) this value 28.11 is written above the original value that has to be crossed by drawing a line through the figure (33.71) in such a way that the value is still readable.

Point 1 has been detected in the Q-D relation of EB 07 and in the Q-Q relation (≡ point 13).
Q-D EB 07 (point 1; fig. 5-7): D too high (+) or Q too low (-).
D-D (D_7 = 2.91; D_8 = 2.93);fig. 5-8: D_7 and D_8 correct (0).
Q-Q point 13; fig. 5-9): Q_7 too low (-) or Q_8 too high (+).
Q-D EB 08 (D = 2.93; Q = 26.02; fig. 5-10): D and Q correct (0).
Matrix EB 07: + - EB 08: 0 0

The velocity of EB 07 for 23/03/80 is liable for correction (matrix configuration 6); for EB 08 no correction is warranted.
Check field measurements (annex 1.4.2) fives Q = 19.33 (float measurements of 23/03/80).
Correction Q EB 07, Q-D: $Q_7 = 0.687\ (2.91)^{3.36} = 24.87$
Q-Q: $Q_7 = (26.02/1.61)^{1/0.838} = 27.68$
Average Q_c = 26.27.

Point 2 has been detected in the Q-D relation of EB 07 (fig. 5-7) and in the Q-Q relation (≡ point 14)
The measurement date is 20/04/80.
Matrix for EB 07: - + / 0 + and for EB 08: 0 0 / 0 -
Correction velocity EB 07 (configuration 2); no correction for EB 08

Check routine measurements (Annex 1.4.2): no deviations.
Correction Q_7 according to Q-D relation: Q_7 = 22.11
Q-Q relation: Q_7 = 22.33
Average Q_c = 22.22

Point 10 had been identified in the D-D relation of 4/05/80 and in the Q-Q relation (≡ point 15).
Matrix for EB 07: 0 0 and for EB 08: 0 0
+ + − −
No correction warranted for both measurement points.

Point 3 has been identified in the Q-D relation of EB 07. Measurment of 26/05/80
Matrix for EB 07: + − and for EB 08: + −
0 − 0 +
Correction velocity of EB 07 (matrix configuration 6); for EB 08 no correction is warranted.
A check of the field measurements of EB 07 for 26/05/80 gives no deviations (data in annex 1.4.2).
Correction Q_7 according to Q-D relation (fig. 5-7): Q_7 = 24.02
Q-Q relation (fig. 5-9): Q_7 = 22.24
Average: Q_c = 23.13.

Point 16 has been identified in the Q-Q relation of 22/09/80
Matrix for EB 07: 0 0 and for EB 08: − +
0 − 0 +
Correction of EB 07 is not warranted; correction velocity of EB 08 (matrix configuration 2).
A check on the field measurements of EB 08 for 22/09/80 (annex 1.5.3.) gives no deviations.
Correction Q_8 according to Q-D relation (fig. 5-10): Q_8 = 35.02
Q-Q relation (fig. 5-9): Q_8 = 30.55
Average: Q_c = 32.79.

Point 6 has been detected in the Q-D relation of EB 08 of 4/10/80 and in the Q-Q relation (≡ point 17)
Matrix for EB 07: − + and for EB 08: − +
0 − 0 +
Correction of Q_8 (matrix configuration 2): Q-D relation Q_8 = 33.18
Q-Q relation Q_8 = 31.98
Average Q_8 = 32.58.

Point 4 has been detected in the Q-D relation of EB 07 of 27/10/80; in the Q-D relation of EB 08 (≡ point 7); in the Q-Q relation (≡ point 18)
Matrix for EB 07: + − and for EB 08 + −
+ + − −
Correction of D_7 is liable (matrix configuration 1 of depth correction possibilities; see text).
Correction of Q_8 is liable (matrix configuration 5 of velocity correction possibilities; see text).
Since the (D_7,D_8) data point has not been identified as unreliable, the most probable correction is the velocity of EB 08.
Correction Q_8 on basis of Q-D relation: Q_8 = 20.34
Q-Q relation: Q_8 = 23.13
Average: Q_c = 21.74.

Point 8 has been detected in the Q-D relation of EB 08 of 11/11/80; in the D-D relation (≡ point 11) and in the Q-Q relation (≡ point 19).
Matrix EB 07: − + and EB 08: + −
− − + +
Correction of depth is liable both for EB 07 and EB 08.
Since the point has not been detected in the Q-D relation of EB 07, correction of D_8 is the most probable.
Checking the routine observation of EB 08 for 11/11/80, it is noticed in annex 1.5.2 that the measured Hm for this date is very low. It looks like a mistake (error reading) of 1 m has been made. If the reading would have been 2.35 instead of 1.35 the water depth at EB 08 would have been 2.92 instead of 3.92.
Correction of D_8 according to Q-D relation gives D_8 = 3.58
D-D relation gives D_8 = 2.90
Most probably a depth measurement error of 1 m has been made: D_c = 2.92.
Using the programme pendulum meter the pendulum velocity is calculated: $\bar{v}_p$ = 0.469.
Taking A = 99.25, c_p = 0.715, c'_D = 0.598 x 2.92 − 0.93, Q_c = 27.17 is calculated.

Point 5 has been identified in the Q-D relation of EB 07 of 7/12/80 and in the Q-D relation of EB 08 (≡ point 9).
Matrix EB 07: + − and EB 08: + −
0 + 0 −
Correction of EB 07 is not warranted; for EB 08 the velocity is liable to correction.
Correction of Q_8 on basis of Q-D relation: Q_8 = 27.71
Q-Q relation: Q_8 = 23.62
Average: Q_c = 25.67.

A summary of the preliminary discharge data correction is given hereafter:

Comparison	No of data corrected (preminilary)			
	first point		second point	
	Q	D	Q	D
FB 03 - FB 04	6	0	3	0
FB 03 - FB 05	1	0	6	1
EB 07 - EB 08	3	0	5	1
EH 11 - EH 13	5	0	0	-
MG 09 - MG 10*	0	-	1	-
WE 10 - WE 11**	0	-	0	-

* - Discharge of april unreliable; Q_9 too high, or Q_{10} too low
Q_9 , average of 1976 - 1979 (data annex 1.9.2) 3.3 % higher than Q_9 of 1980
Q_{10}, average of 1976 - 1979 (data annex 1.9.2) 7.6 % lower than Q_{10} of 1980
Conclusion: correction not warranted.
- Discharge of september unreliable; Q_9 too low, or Q_{10} too high
Q_9 , average of 1976 - 1979 (data annex 1.10.2) 4.9 % higher than Q_9 of 1980
Q_{10} , average of 1976 - 1979 (data annex 1.10.2) 32.8 % higher than Q_{10} of 1980
Conclusion: Q_{10} is liable for correction.
Checking of original data is not possible (visit to the pump station, or to the Regional Irrigation Department may be necessary)
Preliminary correction based on Q-Q relationship: $Q_{10} = 13.54$

** No historical data are available and consequently no data correction can take place.
Remarkable is the relatively great scatter in the Q-Q plot. The reason for this may be the fact that the irrigation water supply to the area draining to WE 10, Edko pump station is mainly drainage water pumped by WE 11, Bosseili pump station. Therefore the irrigation practices most prabably will differ which is reflected in the poor correlation between the discharges of both pump stations.

+ calculate the corrected discharge Q_c according to the routine measurement methods and relations given in chapter 4.1.1.2 or 4.1.1.3.

- Correction of the discharge:
  + calculate the discharge from the Q-D relation using the measured depth as input:
  $Q_D = a\ D^b$
  + calculate the discharge from the Q-Q relation using the 'reliable' discharge as input:
  $Q_Q = a\ Q_r^{\ b}$ or $Q_Q = (a^{-1} Q_r)^{1/b}$
  + calculate the average of both:
  $Q_c = (Q_D + Q_Q)/2$

6. Record the preliminary corrected value's on the calculation sheet in such a way that the original 'unreliable' figures are still visible. See annex 5 for the preliminary corrected data.

For the measurement points that will not be involved in other mutual data consistency analyses (underlined measurement points in annex 4) the missing data may be estimated. If no velocity measurements have been performed, the missing discharge may be taken as the average of the discharge derived from the stage - discharge relation and that from the discharge double mass relation. If also no water depth measurements have been performed the missing water depth measurement should be estimated from the depth double mass relation before the discharge can be estimated. For pump stations, only the discharge double mass relation can be used.

The procedure for the estimation of missing discharge data is as follows (see also example 5-6):

1. Check in annex 4 which one of the measurement points used for the double mass analysis is underlined.
2. Determine for the date of measurement for which no depth measurements have been collected the depth using the D-D double mass relation.
3. Determine for the measurement date for which no discharge is known the discharge using the stage - discharge relation (if applicable) and using the Q-Q double mass relation and calculate the average.
4. Record the estimated data on the calculation sheet and indicate with an asterix (*) or another sign the estimated data in order to distinguish them from the actual measured data (see example 5-6).

Example 5-6. Estimation missing discharge data

The data of EB 07, Bahr Baqar drain at 'Kubri Saud' and EB 08, Bahr Baqar drain at 'Kubri Bahr Baqar' have been used for illustration in this example (Annex 3.4 and 3.5). See also example 5-5.

Step 1. Check annex 4.
See annex 4.2: EB 07 is underlined; the missing data for this point can be estimated.

Step 2. On 18/08/80 no discharge measurements for EB 07.
From the D-D relation (fig. 5-8, example 5-5), it follows $D_7 = (2.88/1.13)^{1/0.849} = 3.01$

Step 3. From the stage - discharge relation (fig. 5-7, example 5-5) it follows $Q_7 = 0.687\ (3.01)^{3.36} = 27.86$
From the Q-Q relation (fig. 5-9, example 5-5) it follows $Q_7 = (27.20/1.61)^{1/0.838} = 29.18$
The average of both: $Q_7 = (27.86 + 29.18)/2 = 28.52$.

Step 4. Record the missing data D = 3.01. Q = 28.52 on the calculation sheet (see annex 5.4).

A summary of the estimation of missing data is given below:

Measurement point for which missing data are estimated (annex 4)	Number of data estimated	
	depth	discharge
FB 03	0	0
FB 04	1	1
EB 07	1	1
EH 11	0	0
EH 13	-	0
MG 09	-	0
WE 10	-	1
WE 11	-	0

5.2. Water quality consistency analysis

Three relations can be used for the waterquality data consistency analysis. In chapter 4.2 the 'theoretical' relation between the concentration of the cations and anions and the electrical conductivity has been treated(eqs. (4-46) - (4-57)).

A diviation of the EC calculated according to these equations (HP 97 programme 'Water quality processing', annex 8.3) of more than 10 % from the EC measured in the laboratory is an indication of unreliability of the measurements. Another possibility of identification of unreliable measurement is due to the method of calculation of the SO_4^{2-} concentration (as the difference between cations and other anions). If this calculated SO_4^{2-} concentration becomes negative (see for example annex 2.10, water quality measurements of 22/02/81) most likely a mistake in the measurements has been made.

Unlike other ions such as Ca^{2+}, Mg^{2+}, HCO_3^- and SO_4^{2-} the Na^+ and Cl^- concentrations are not limited by precipitation of salts and complexation equilibria. Because of the precipitation of salts of other ions it may be expected that the relative importance of both the Na^+ and Cl^- ions will increase with increasing salinity. For the relation between the EC and [Na] and [Cl] respectively a power curve may therefore be expected:

$$EC = a_n\ [Na]^{b_n} \qquad (5\text{-}13a)$$

$$EC = a_l\ [Cl]^{b_l} \qquad (5\text{-}13b)$$

where: EC = electrical condustivity in $mmho.cm^{-1}$
a_n, b_n, a_l, b_l, = regression constants
[Na] - Na^+ = concentration in $meq.l^{-1}$
[Cl] - Cl^- = concentration in $meq.l^{-1}$

Unreliable data points can be identified by comparing the fractional EC difference with a pre-determined criterium (= 0.20):

$$|\Delta EC| = \frac{\widetilde{EC} - EC_m}{EC_m} \geq 0.20 \qquad (5\text{-}14)$$

where: ΔEC = fractional EC difference
if $|\Delta EC| \geq 0.20$ the measurements are considered unreliable
$\widetilde{EC}$ = calculated EC according to equation (5-13) using the measured concentration of Na or Cl as input
EC_m = measured electrical conductivity

For the preliminary correction of unreliable water quality measurements the Na and Cl concentrations and the electrical conductivity are considered. In order to facilitate the selection of the parameter Na, Cl, or EC for which a preliminary correction is most probable a simple qualitative matrix consisting of three elements can be used. The general form of this matrix is as follows:

	EC_m (measured)	Comments
EC_p (eqs. (4-46)-4-57))	.	HP 97 programme 'Water quality processing'
EC_n (eq. (5-13a))	.	EC-Na relation
EC_l (eq. (5-13b))	.	EC-Cl relation

The element M(1) is filled with an (-) if $EC_m - EC_p < -0.05$, where EC_m is the measured EC and EC_p is the calculated EC using the measured cation and anion concentrations as input for equations (4-46) - (4-57); the element M(1) is filled with an (o) if $-0.05 < EC_m - EC_p < 0.05$; and with an (+) if $EC_m - EC_p > 0.05$. The element M(2) is filled with an (-) if the (EC, Na) data pair in the EC-Na plot is clearly below the empirical EC-Na relation; with an (o) if the data pair is on the relation, or very close to it; and with an (+) if the (EC, Na) data pair is clearly above the empirical EC-Na relation. The third element M(3) is filled with an (-) if the (EC, Cl) data pair is above the EC-Cl relation; with an (o) if the data pair is on or very close to this relation; and with an (+) if the data pair is above the relation.

Based on the actual configuration of the matrix the decision can be made to correct the Na^+ concentration, the Cl^- concentration, the EC, or to maintain the measurements, as they have been reported by the laboratory.

The correction of the Na^+ concentration is according to equation (5-13a) using the measured EC_m as input:

$$\widetilde{Na} = (EC_m/a_n)^{1/b_n} \qquad (5\text{-}15a)$$

where: $\widetilde{Na}$ = corrected Na concentration in $meq.l^{-1}$.

Concequently the SO_4 concentration changes (Σcations-Σanions). The correction of Na and SO_4 concentrations must be checked by calculating the EC_p with eqs. (4-46) - (4-57) using the corrected Na and SO_4 values as input. The corrected EC_{pc} should not deviate more than 10 % from the measured EC_m value:

$$0.9\ EC_{pc} < EC_m < 1.1\ EC_{pc} \qquad (5\text{-}15b)$$

where: EC_{pc} = calculated EC_p value using the corrected Na and SO_4 concantration as input

The correction of the EC, if appropriate, is performed by calculating the average of the calculated EC_p based on the measured cation and anion concentration (eqs. (4-46) - (4-57)), the EC calculated with eq. (5-13a) using the measured Na concentration as input and eq. (5-13b) using the measured Cl concentration as input:

$$EC_c = (EC_p + \widetilde{EC}_n + \widetilde{EC}_l)/3 \qquad (5\text{-}16a)$$

where: EC_c = corrected EC in $mmho.cm^{-1}$

EC_p = EC, calculated with programme 'Water quality processing'

$EC_n = a_n\ [Na_m]^{b_n}$

Na_m = measured Na concentration in $meq.l^{-1}$

$EC_l = a_l\ [Cl_m]^{b_l}$

Cl_m = measured Cl concentration in $meq.l^{-1}$

The corrected EC_c value must be checked against the calculated EC_p value:

$$0.9\ EC_p \leq EC_c \leq 1.1\ EC_p \qquad (5\text{-}16b)$$

If the correction of the Cl concentration is appropriate equation (5-13b) can be used:

$$\widetilde{Cl} = (EC_m/a_l)^{1/b_l} \qquad (5\text{-}17)$$

where: $\widetilde{Cl}$ = corrected Cl concentration in $meq.l^{-1}$.

The SO_4 concentration changes complementary according to the Σcations - Σanions calculation.

The flow diagramme of the procedure for water quality data correction based on the qualitative matrix is presented in fig. 5-11.

The complete procedure for the identification of unreliable water quality measurements and the preliminary data correction is given below (see also example 5-7):

1. Prepare a list of data including the data of measurement, the EC, the Na and the Cl concantration. Reserve a column behind the column for EC for the EC_p values, behind the column for Na for the ΔEC_n values and behind the Cl column for the ΔEC_l values. See table 5-4. Indicate on the list with an(+) or an (-) for which dates the EC_m is inconsistent with the chemical composition. This can be taken from the calculation sheets (see annex 2).
2. Prepare a plot of the (EC, Na) data pairs and the (EC, Cl) data pairs (see figs. 5-12 and 5-13). Indicate on the plot the data pairs for which the EC does not match the chemical composition. Identify (EC, Na) and/or (EC, Cl) data pairs that are obviously far outside the normal range of data scatter. Indicate these unreliable pairs by marking them in the list with an asterix (*) behind the Na observation if it concerns the EC-Na plot and behind the Cl observation if it concerns the EC-Cl plot.
3. Establish the EC-Na relation by curve fitting using the (EC, Na) data pairs excluding the identified unreliable data pairs and the standard HP 97 programme 'Curve fitting' with the power curve option (press f E). Draw the curve in the EC-Na plot (see fig. 5-14) and calculate the fractional EC difference according to equation (5-14). Record the ΔEC values in the list (see table 5-4).
   Repeat this procedure for the (EC, Cl) data pairs. See fig. 5-15 and table 5-4.

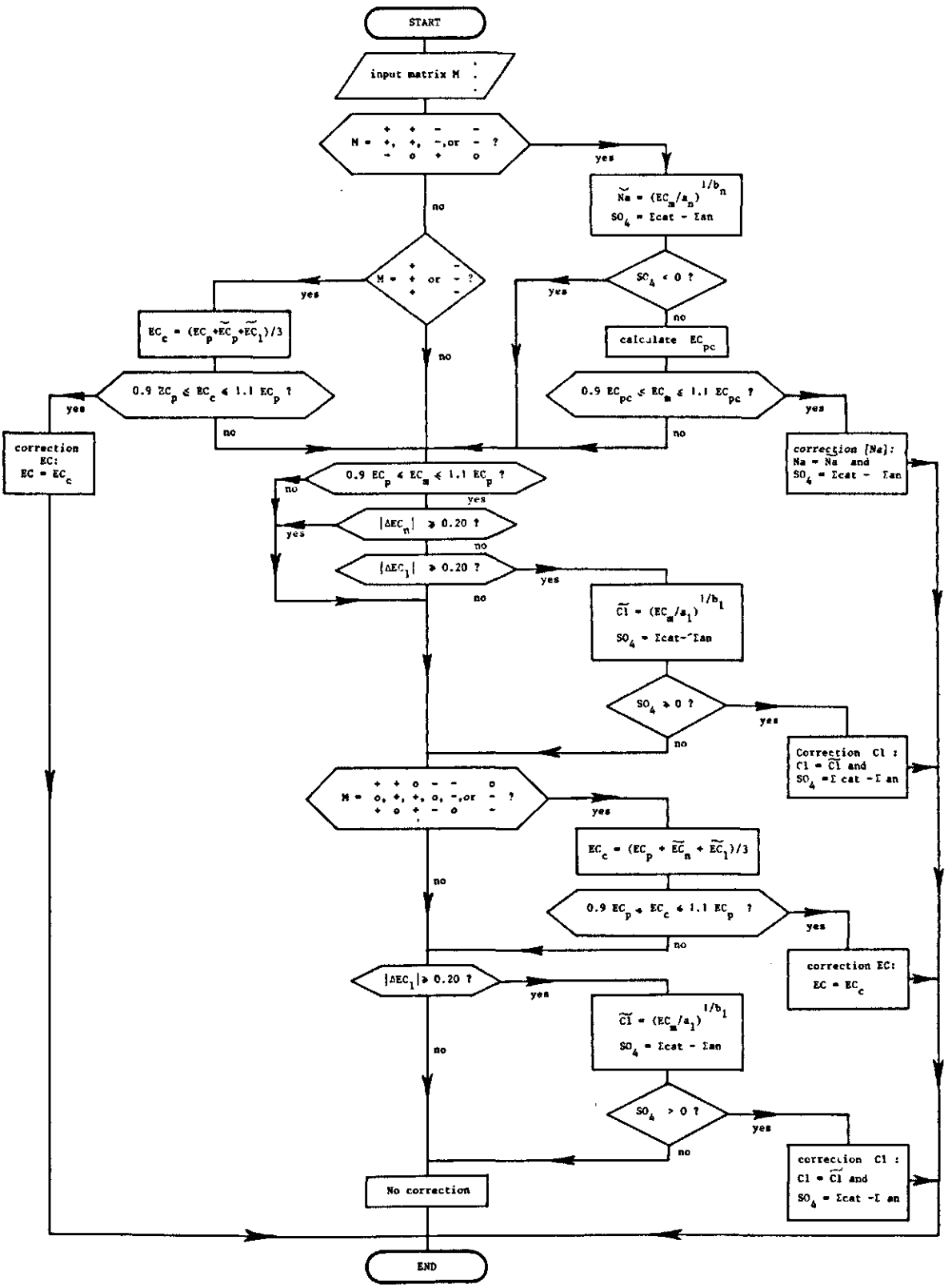


Fig. 5-11. Flow diagram preliminary water quality data correction

Example 5-7. Identification unreliable water quality measurements and preliminary data correction.
The data used are of MG 10, pump station No. 3, see annex 2.10.

Step 1. Prepare list of data. See table 5-4

Date	EC_m	EC_p	Na	ΔEC_n	Cl	ΔEC_l	Identification number
23/01	2.37		15.0	0.04	11.3	-0.15	
9/02	8.31	8.07	51.1	-0.24	63.8	-0.11	10
22/02	2.26		15.7	0.13	15.8	0.14	
6/03	2.03	2.14	12.5	0.06	14.9	0.22	11
21/03	2.83	3.26	20.0	0.09	23.5	0.23	12
4/04	1.92	2.08	12.0	0.09	13.5	0.20	13
16/04	2.29		13.0	-0.03	13.5	-	
16/05	2.04		13.8	0.14	10.4	-0.07	
20/05	2.04		10.5	-0.08	11.5	-	
9/06	2.30		15.2	0.09	15.0	0.08	
22/06	2.83		19.0	0.05	15.1	-0.12	
8/07	2.73		17.7	0.03	17.5	0.02	
25/07	2.21		14.0	0.06	13.0	0.01	
7/08	1.91	2.23	13.5	0.20	13.0	0.17	14
30/08	2.00		12.4	0.07	12.8	0.10	
14/09	2.73		18.0	0.04	13.3	-0.17	
27/09	2.82		17.5	-0.01	16.6	-0.05	
15/10	1.69	1.58	5.8	-0.29	5.9	-0.27	15
6/11	1.00	1.06	4.6	-	6.0	0.25	16
20/11	2.49		14.6	-0.03	17.0	0.10	
30/12	3.64	4.14	32.0	0.22	22.1	-0.09	17

Table 5-4. MG 10. list of (EC, Na, Cl) data pairs and identification unreliable measurements

Step 2. Prepare EC-Na plot (fig. 5-12)and EC-Cl plot (fig. 5-13.).
Identify data points far outside normal scatter: no points

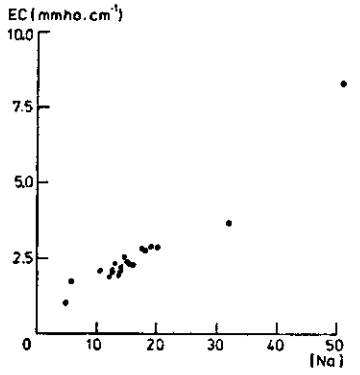


Fig. 5-12. MG 10, EC - Na plot

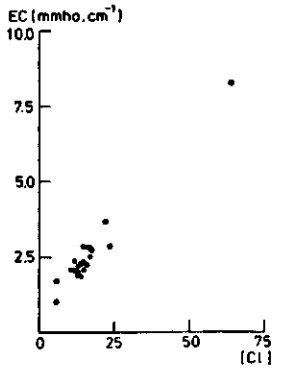


Fig. 5-13. MG 10, EC - Cl plot

Step 3. Establish EC-Na relation: $EC = 0.311\ [Na]^{0.766}$, $R^2 = 0.90$. Draw curve in plot. See fig. 5-14.

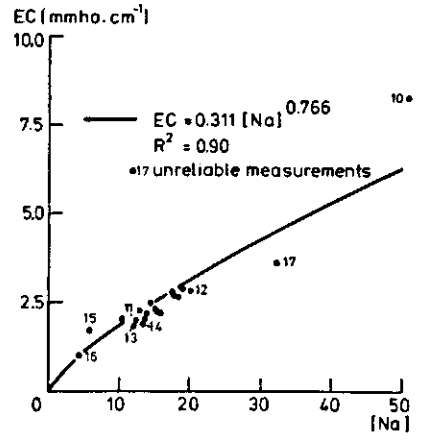


Fig. 5-14. MG 10, EC-Na relation and unreliable data points

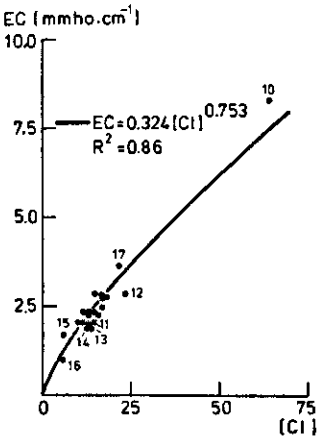


Fig. 5-15. MG 10, EC-Cl relation and unreliable data points

Calculate EC_n; enter Na_m; press E; enter EC_m; press - ; enter EC_m; press + ; displays EC_n
for example 23/01:
15 press E displays 2.48; 2.37 press displays 0.11; 2,37 press + displays 0.04;
record in table 5-4 $\Delta EC_n = 0.04$
Establish EC-Cl relation: $EC = 0.324\ [Cl]^{0.753}$, $R^2 = 0.86$. Draw curve in plot. See fig. 5-15.
Calculate ΔEC_l and record in list. See table 5-4.

Step 4. Identify and number unreliable points:
- point 10 (table 5-4 EC - Na relation
- point 11 -"- EC - Cl relation
- point 12 -"- HP 97 programme 'Water quality processing'

Record on list (table 5-4) and figures 5-14 and 5-15.
Calculate EC_p for unreliable measurements. See table 5-4. Data from annex 2.10. Programme instructions in annex 8.3.

Step 5. Corrections:
- point 10: HP 97 programme (table 5-4). $EC_m - EC_p = 0.23$; M(1) = +
EC - Na relation (fig. 5-14) point above the relation; M(2) = +
EC - Cl relation (fig. 5-15) point above the relation; M(3) = +

$M = \begin{pmatrix} + \\ + \\ + \end{pmatrix}$; according to fig. 5-11: correction of EC:

+ $EC_p = 8.07$ (HP 97 programme)
+ $\widetilde{EC}_n = 0.311\ (51.1)^{0.766} = 6.33$ (equation (5-13))
+ $\widetilde{EC}_l = 0.324\ (63.8)^{0.753} = 7.41$ (equation (5-13))

$EC_c = (8.08 + 6.33 + 7.41)/3 = 7.27$. This is less than 0.9 EC_p (= 7.26). Therefore the correction of EC is not allowed.

The E_m value (8.31) is not deviating more than 10 % from EC_p.
The point has been detected in the EC-Na relation ($|\Delta EC_n| > 0.20$);see flow diagramme, fig. 5-11).
Conclusion: no corrections for this 'unreliable' measurement.

- point 11:

$M = \begin{pmatrix} - \\ o \\ - \end{pmatrix}$; according to fig. 5-11: correction of Cl ($|\Delta EC_l| \geq 0.20$)

+ $\widetilde{Cl} = (2.03/0.324)^{1.33} = 11.4$ (equation 5-17)
+ $SO_4 = (20.1 - 14.9) = 5.2$ ($\Sigma cat - \Sigma an$; data of 6/03; annex 2.10)
SO_4 is not negative. Conclusion: correction of Cl is appropriate.

- point 12:

$M = \begin{pmatrix} - \\ - \\ - \end{pmatrix}$; according to fig. 5-11 : correction of EC

+ $EC_p = 3.26$ (HP 97 programme)
+ $\widetilde{EC}_n = 0.311\ (20)^{0.766} = 3.09$ (equation 5-13)
+ $\widetilde{EC}_l = 0.324(23.5)^{0.753} = 3.49$ (equation 5-13)

$EC_c = (3.26 + 3.09 + 3.49)/3 = 3.28$. This value is not deviating more than 10 % from EC_p.
Conclusion: correction of EC is appropriate.

- point 13:

$M = \begin{pmatrix} - \\ o \\ - \end{pmatrix}$; according to fig. 5-11: correction of Cl ($|\Delta EC_l \geq 0.20$)

+ $\widetilde{Cl} = (1.92/0.324)^{1.33} = 10.6$ (equation 5-17)
+ $SO_4 = 20 - 14.2 = 5.8$ ($\Sigma cat - \Sigma an$; data of 4/04; annex 2.10)
The SO_4 concentration is positive.
Conclusion: correction of Cl appropriate.

- point 14:

$M = \begin{pmatrix} - \\ - \\ o \end{pmatrix}$; according to fig. 5-11: correction of Na

+ $\widetilde{Na} = (1.91/0.311)^{1.31} = 10.7$ (equation 5-15a)
+ $SO_4 = 19.4 - 18.2 = 1.2$ ($\Sigma cat - \Sigma an$; data of 7/08; annex 2.10)

+ EC_p : Ca = 4.2; Mg = 4.3; Na = 10.7; K = 0.2; $CO_3 = 0.0$; $HCO_3 = 5.2$; $SO_4 = 1.2$; Cl = 13.0
Programme 'Water quality processing : $EC_p = 2.02$
The EC_m value (1.91) is not deviating more than 10 % from this calculated value (2.02).
Conclusion: correction of Na is appropriate.

- point 15:

$M = \begin{pmatrix} + \\ + \\ + \end{pmatrix}$; according to fig. 5-11: correction of EC

+ $EC_p = 1.58$ (HP 97 programme)
+ $\widetilde{EC}_n = 0.311\ (5.8)^{0.766} = 1.20$ (equation 5-13)
+ $\widetilde{EC}_l = 0.324\ (5.9)^{0.753} = 1.23$ (equation 5-13)

$EC_c = (1.58 + 1.20 + 1.23)/3 = 1.34$. This is less than 0.9 EC_p (= 1.42). Correction of EC is therefore not allowed.

The EC_m value is not deviating more than 10 % from EC_p (fig. 5-11).
The point is found deviating in the EC-Na relation ($\Delta^p EC_n$ = - 0.29).
The point is also found deviating in the EC-Cl relation (ΔEC_l = - 0.27)
According to fig. 5-11: correction of Cl

+ Cl = $(1.69/0.324)^{1.33}$ = 9.0 (equation (5-17))
+ SO_4 = 16.9 - 15.4 = 1.5 (Σcat - Σan; data of 15/10; annex 2.10)
The calculated SO_4 concentration is not negative.
Conclusion: correction of Cl is the only appropriate correction to be applied.

- point 16:

M = $\begin{pmatrix} - \\ o \\ - \end{pmatrix}$; according to fig. 5-11: correction of Cl (ΔEC_l = 0.25)

+ Cl = $(1.000/0324)^{1.33}$ = 4.5 (equation 5-17)
+ SO_4 = (10 - 7.7) = 2.3 (Σcat - Σan; data of 6/11; annex 2.10
Conclusions: correction of Cl is appropriate.

- point 17:

M = $\begin{pmatrix} - \\ - \\ o \end{pmatrix}$; according to fig. 5-11: correction of Na

+ Na = $(3.64/0.311)^{1.31}$ = 2.48 (equation (5-15a))
+SO_4 = 35.8 - 26.8 = 9.0 (Σcat - Σan)
+EC_p = 3.51 (Ca = 4.8; Mg = 5.6; Na = 24.8; K = 0.6; CO_3 = 0.0; HCO_3 = 4.7; SO_4 = 9.0; Cl = 22.1)
The EC_m value (3.64) is not deviating more than 10 % from this EC_p value.
Conclusion: correction of Na is appropriate.

The corrected values are presented in annex 5.9

A summary of the preliminary water quality data corrections for the measurement points of annex 2 is given below. The data used are taken from annex 2 and the resulting preliminary corrections are presented in annex 5.

Measurement point	Regression coefficients						Number of unreliable data				Number of corrections			
	a_n	b_n	R^2	a_l	b_l	R^2	HP 97 progr.	EC-Na	EC-Cl	Total	EC	Na	Cl	Total
FB 03	0.298	0.767	0.89	0.304	0.820	0.90	2	3	4	6	3	0	1	4
FB 04	0.274	0.806	0.96	0.321	0.830	0.96	2	3	4	7	1	1	3	5
FB 05	0.267	0.817	0.96	0.294	0.848	0.90	1	2	5	8	1	1	5	7
EB 07	0.635	0.397	0.55	0.742	0.335	0.22	0	3	5	7	3	0	2	5
EB 08	0.659	0.384	0.56	0.745	0.320	0.12	1	3	6	8	3	0	2	5
EH 11	0.424	0.677	0.89	0.642	0.511	0.69	2	3	5	7	1	2	4	7
EH 13	0.322	0.769	0.90	0.403	0.695	0.80	0	1	5	6	0	0	5	5
MG 09	0.388	0.686	0.79	0.375	0.673	0.82	0	5	2	7	2	0	1	3
MG 10	0.311	0.766	0.90	0.324	0.753	0.86	3	4	5	8	1	2	4	7
WE 10	0.309	0.772	0.96	0.196	0.917	0.86	2	0	8	8	1	0	7	8
WE 11	0.275	0.815	0.98	0.237	0.881	0.88	2	1	5	6	3	0	2	5

4. Identify and number the unreliable measurements in the list (see table 5-4) and in the figures 5-14 and 5-15. Calculate the EC_p with the HP 97 'Water quality processing' programme for the identified unreliable measurements and record these values on the list (see table 5-4).
5. For all unreliable points found in one or more of the relations:
   - prepare the qualitative matrix
   - preliminary correct the EC, Na or Cl values according to the decision structure given in the flow diagramme of fig. 5-11.
   - record the correction on the calculation sheet by writing the corrected value above the original and crossing out the original in such a way that the value is still visible. See annex 5 for the preliminary corrected data.

5.3. Salt double mass analysis

In the salt double mass analysis the salt loads of nearby located catchment areas are compared. The purpose of the comparison is two-fold: detection of the possible occurence of exchange of watersamples and a check on the preliminary corrections in discharge, electrical conductivity, sodium and chloride concentrations that have been applied previously.
For the mutual comparison use has to be made of the electrical conductivity, the sodium load and the chloride load. The last two parameters can be defined:

$$L_{Na} = Q\ [Na] \qquad (5\text{-}18a)$$

and

$$L_{Cl} = Q\ [Cl] \qquad (5\text{-}18b)$$

where L_{Na} = Na-load in $eq.s^{-1}$
Q = discharge in $m^3.s^{-1}$

$[Na]$ = Na concentration in meq.l^{-1}

L_{Cl} = Cl load in eq. s^{-1}

$[Cl]$ = Cl concentration in meq.l^{-1}

The actual double mass analysis has to be done by employing enveloping curves parallel to the power curve:

$$EC_j = a_e\ (EC_i)^{b_e} \qquad (5\text{-}19a)$$

$$(L_{Na})_j = a_n\ \{(L_{Na})_i\}^{b_n} \qquad (5\text{-}19b)$$

and

$$(L_{Cl})_j = a_c\ \{(L_{Cl})_i\}^{b_c} \qquad (5\text{-}19c)$$

where:

a_e, a_n, a_c, b_e, b_n, and b_c are regression constants

j and i are the subscripts for the measurement point identification

If one, or both of the measurement points i and j is an irrigation pump station the discharges do not necessarily have to be correlated and in this case the sodium and chloride concentrations have to be used in equation (5-19) without multiplication with discharge according to equation (5-18).

For the estimation of missing water quality data use can be made of the EC-EC relation (5-19a) and the EC-Na (5-15a) and EC-Cl relation (5-17). Assuming for the other ions in the drainage water a constant ionic distribution with respect to the preceding and succeeding data of measurement the following relation can be used for the ionic concentration:

$$[i]_d = \frac{[i]_{d-1} + [i]_{d+1}}{[Na]_{d-1}+[Na]_{d+1}+[Cl]_{d-1}+[Cl]_{d+1}}\{[Na]_d+[Cl]_d\} \qquad (5\text{-}20)$$

where:

$[i]_d$ is the estimated concentration of the ion in question ($i = Ca^{2+}, Mg^{2+}, K^+, CO_3^{2-}, HCO_3^-, H^+$) for the the measurement date d in meq.l^{-1}

$[i]_{d-1}$ = measured concentration of ion i for the preceding measurement date

$[i]_{d+1}$ = concentration of ion i on the succeeding measurement date

It should be kept in mind that the $[H^+]$ is related to the pH:

$$[H^+] = 10^{-pH} \qquad (5\text{-}21)$$

where: pH = acidity

The complete procedure for the salt double mass analysis and the estimation of missing water quality data is as follows (see also example 5-8):

1. Prepare for the measurement points, that have to be compared according to annex 4 and for which the preliminary corrections in discharge and water quality have been applied, a list with the date of measurement, the EC of both points, and the Na- and Cl-loads of both points. Indicate for each item and for each date for each point with an astrix (*) if a preliminary correction has been applied in the EC, the Na- or Cl-concentration, or in the discharge. See table 5-5 in example 5-8.
2. - Prepare a plot of EC_i against EC_j. Distinguish between the (EC, EC) data pairs for which no corrections have been made and the preliminary corrected values (see fig. 5-16).
   Identify the (EC, EC) data pairs that are far outside the 'normal' range of data scatter in the points. It is likely that for these points an exchange of water samples between different measurement points has occurred. Label these points by giving them a number, both in the list (see table 5-5) and in the plot (see fig. 5-16).
   - Prepare next a plot of $(L_{Na})_i$ against $(L_{Na})_j$. Distinguish between the data pairs with and those without corrections (see fig. 5-17). Identify the data pairs that are far outside the 'normal' range of data scatter. Label these points by numbering in the list and in the plot.
   - Prepare a plot of $(L_{Cl})_i$ against $(L_{Cl})_j$. Distinguish between the data pairs with and those without preliminary corrections (see fig. 5-18). Identify the data pairs that are far outside the normal range of data scatter. Label these points by numbering in the list (see table 5-5) and in the plot (see fig. 5-18).
3. Use the data pairs in the list (see table 5-5) excluding the unreliable data pairs identified in one or more of the plots to establish the power curve relationship between the EC's and the Na- and Cl-salt loads of the measurement points that have to be compared. Draw the power curve in the plots and draw parellel to these curves enveloping curves enclosing the data pairs for which no preliminary corrections have been applied (with possible exception of the data pairs identified as unreliable). See figs. 5-19, 5-20 and 5-21. Record the regression constants of the EC-EC relation in the figure for possible future use (see fig. 5-19). Identify additional unreliable data points (= preliminary corrected data that are outside the area enclosed by the enveloping curves). Number these data points both in the list and in the figures (see example 5-8).
4. Check the unreliable data points in the EC-EC relationship. The points seriously deviating from the relation found most probably have been caused by the exchange of water sample bottles.

If the deviation in the EC-value is in the point that will not be involved in further data checking the whole analysis may be estimated following the next steps:

- calculate the EC from the EC-EC relation
- calculate the Na and Cl concentration using the EC-Cl and EC-Na relations derived for the measurement point in question.
- check whether the Na-load and Cl-load according to this estimated concentrations is within the area enclosed by the enveloping curves.
- calculate the other ions using equation (5-20) and the pH using equation (5-21).

If the deviation in the EC-value is obviously in the point that will be involved in further data checking (see annex 4) it can be maintained as it is here, and it will be corrected in the next mutual cross-check.

5. Check the preliminary corrected data that are outside the area enclosed by the enveloping curves. Check whether the original (un-corrected) data would move the data point in question closer to the relation found (see example 5-8). If so, the preliminary correction has to be removed and the original data have to be used.
6. Record the estimated data on the calculation sheets replacing the wrong data and restore the original values for those data that have been preliminary corrected but for which the correction proved to be not allowed.
7. Following the sequenting list of measurement points given in annex 4 the finally corrected data sheets for the underlined measurement points are ready to be prepared for the data presentation.

Example 5-8. Final data correction.

The data used are of EB 07 and EB 08, see annex 5.4 and 5.5

Step 1. Prepare a list of EC, L_{Na} and L_{Cl} data (see table 5-5)

Step 2. Prepare plots of EC-EC; L_{Na}-L_{Na}; and L_{Cl}-L_{Cl} (see figs. 5-16, 5-17, 5-18)

Indentify and label unreliable data points far outside the normal range in these plots: points 1 and 2 in fig. 5-16 and 3, 4 and 5 in fig. 5-18.

Date	EC_7	EC_8	L_{Na_7}	L_{Na_8}	L_{Cl_7}	L_{Cl_8}	Identification
20/12	1.02	1.04	211	173*	173	189*	
6/01	1.18	1.16	156	126*	110	129*	
27/01	1.46	2.21	173	135	173	151	1
10/02	1.45	1.70	103	176	95	149	
25/02	1.79	1.02	406	-	325	-	2
9/03	1.17*	1.14*	37*	66	132*	93	
23/03	1.28*	1.37*	184*	224	95*	94*	
13/04	1.16	1.22	126*	111	124*	99*	
20/04	1.12	1.16	122*	104	89*	87	
4/05	1.22	1.21	138*	62	105*	69	
26/05	1.00	1.04	69*	80	79*	89	
3/06	1.07	1.10	101	92	83*	97	
15/06	1.04	1.11	106	126	72*	114	
29/06	1.13*	1.11*	110	115	129	102	
16/07	1.36*	1.29*	211	188	166	125	6
31/07	1.04	1.09	143*	136	133*	133	
18/08	1.02	1.13	114*	112*	103*	133*	
22/09	1.06	1.11	168	161*	137	134*	
4/10	1.13	1.15	149	124*	127	130*	
27/10	1.15	1.15	75	111*	127	111*	
11/11	1.16	1.18	161	87*	151	117*	
24/11	1.66	1.67	181	165*	110*	124*	
7/12	1.47	1.61*	116	187*	190*	110*	4
25/12	1.40	1.32*	303	259	177	84*	5
7/01	1.27	1.44	147	219	91	222*	3

* Preliminary corrections of EC, [Na], [Cl], or Q have been applied

Table 5-5. List of EC, Na-load and Cl-load data pairs EB 07 and EB 08

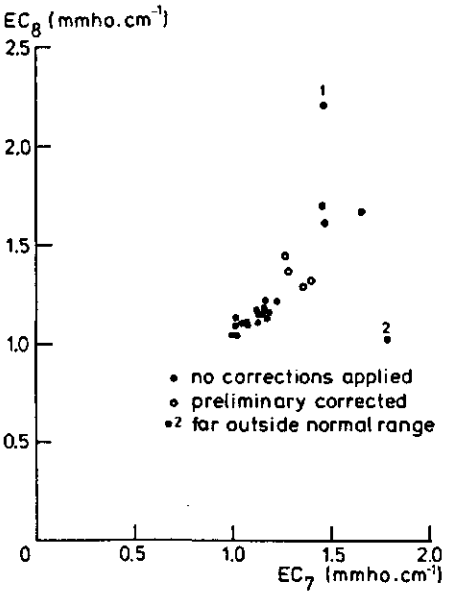


Fig. 5-16. EB 07 and EB 08, EC-EC plot and unreliable data points

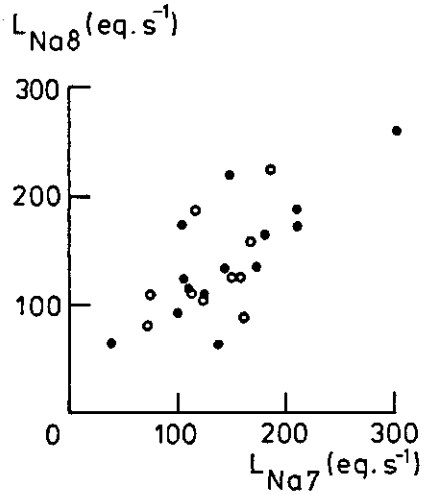


Fig. 5-17. EB 07 and EB 08, L_{Na}-L_{Na} plot

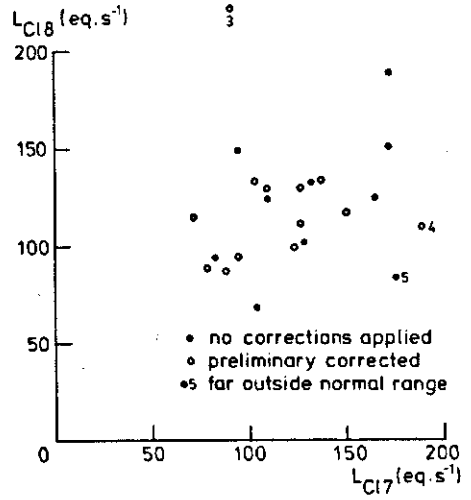


Fig. 5-18. EB 07 and EB 08, L_{Cl}-L_{Cl} plot and unreliable data points

Step 3. Power curve relationship: $EC_8 = 1.03\ (EC_7)^{0.977}$, $R^2 = 0.87$

$L_{Na8} = 9.40\ (L_{Na7})^{0.529}$, $R^2 = 0.41$

$L_{Cl8} = 14.96\ (L_{Cl7})^{0.427}$, $R^2 = 0.21$

Draw the power curves in the plots and draw enveloping curves (see figs. 5-19, 5-20 and 5-21). Identify additional unreliable points in these plots: point 6 in fig. 5-19.

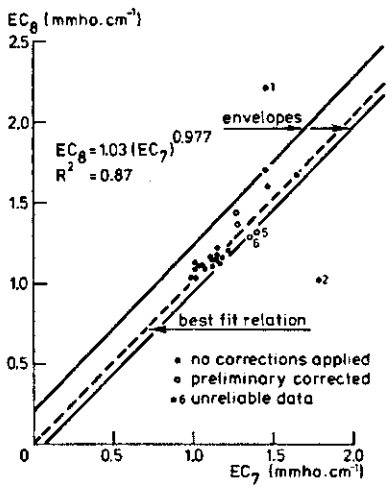


Fig. 5-19. EB 07 and EB 08, EC-EC relation with enveloping curves and unreliable data points

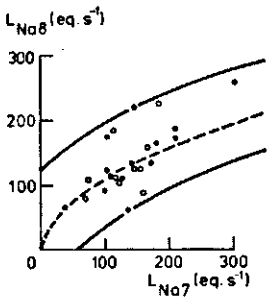


Fig. 5-20. EB 07 and EB 08, Na-load relation with enveloping curves and unreliable data points

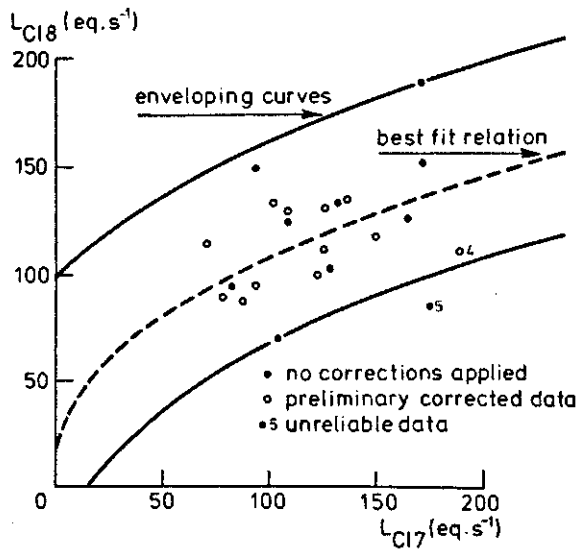


Fig. 2-21. EB 07 and EB 08, Cl-load relation with enveloping curves and unreliable data points

Step 4. Check the EC-EC relation with respect to the seriously deviating data pairs

- point 1 is seriously deviating in the EC-EC relation.
  Checking annex 5.4 and 5.5 for the measurement date of 27/01/80 it can be seen that the measurement of EC at EB 08 was considered too high in relation to the EC_p calculated based on the chemical composition. The point has not been corrected in the water quality data checking procedures indicating that the evidence for correction EC, Na or Cl concentration is conflicting. Most probably (part of) the water samples has been exchanged and the water quality data for EB 08 on 27/01/80 have to be estimated.
  According to annex 4.2.1 EB 08 will be used again in mutual data comparison with EB 09 and with EB 11. Therefore the estimation of these data is postponed till the measurement point will be compared with EB 11.

- point 2 is seriously deviating in the EC-EC relation.
  Checking annex 5.4 and 5,5 for the measurement date of 25/02/80 no deviations are found.
  Based on the electrical conductivity behaviour of EB 06 and EB 11 it becomes clear that on 25/02/80 the effect of the winter closure period has vanished already (date not given in this report).
  Consequently the water quality data for EB 07 have to be estimated.
  The EC is calculated from the EC-EC relation:

$$EC_7 = \left(\frac{1.02}{1.03}\right)^{1/0.977} = 0.99$$

  The Na concentration from the EC-Na relation (see example 5-7)

$$Na = \left(\frac{0.99}{0.635}\right)^{1/0.397} = 3.1$$

  and the Cl concentration from the EC-Cl relation=

$$Cl = \left(\frac{0.99}{0.742}\right)^{1/0.335} = 2.4$$

  On the preceding date 10/02/80 the sum of Na+Cl = 11 (see annex 5.4)
  On the succeeding date 9/03/80 the sum of Na+Cl = 5.5

  Application of equation (5-20) gives:

$$Ca = \frac{4.7 + 5.2}{11 + 5.5}(3.1 + 2.4) = 3.3$$

$$Mg = \frac{3.3 + 5.2}{16.5}\ 5.5 = 2.8$$

$$K = (0.2 + 0.2)\ 0.32 = 0.1$$

$$HCO_3 = (7.4 + 5.2)\ 0.32 = 4.2$$

$$SO_4 = \Sigma cat - \Sigma an = 2.7$$

$$pH = -\log\{(10^{-7.6} + 10^{-7.7})\ 0.32\} = 7.8$$

  To check the interpolated data the HP 97 programme 'Water quality processing' is used:

  SAR = 1.8; adj. SAR = 4.1; RSC = 0.0; EC_c = 0.90; TDS = 650
  The interpolated EC value is thus in agreement with the interpolated chemical composition.

- On 23/03 the pH has not been measured
  By interpolation: $pH = -\log\{(10^{-7.7} + 10^{-7.5}) \times \frac{10.6}{5.5+10.1}\} = 7.5$
  The estimated data are recorded on the calculation sheet (see annex 6.3)

Step 5. Check the preliminary corrected data outside the area enclosed by the enveloping curves.

- EC-EC relation (fig. 5-19)
  + point 5, measurement date 25/12/80; the EC of EB 08 has been preliminary corrected. The original value was 1.55 (see annex 2.5.2). Using this value point 5 moves to within the enveloping curves in fig. 5-19.
    Conclusion: correction of EC of EB 08 on 25/12/80 has to be deleted.
  + point 6, measurement date 16/07/80; the EC of EB 07 and EB 08 have been prelimenary corrected. The original values were 1.20 for EB 07 (see annex 2.4.2) and 1.13 for EB 08 (see annex 2.5.2). Using both original values the point moves but stays an equal (small) distance below the lower envelope of fig. 5-19.
    Conclusion: the corrections of EC of EB 07 and EB 08 on 16/07/80 can be maintained.

- L_{Na}-L_{Na} relation (fig. 5-20)
  + no points outside the enveloping curves

- L_{Cl}-L_{Cl} relation (fig. 5-21)
  + point 3, measurement date 7/01/81; the L_{Cl} of EB 08 has been corrected. According to annex 5.5 the Cl concentration of EB 08 has been prelimenary corrected. The original Cl concentration was 3.5 (see annex 2.5.2). Using the original Cl concentration 3.5 and multiplying with discharge (28.50; annex 5.5) a Cl load of 100 can be calculated. Using this value point 3 moves well within the area enclosed by the enveloping curves in fig. 5-21.
    Conclusion: the correction of Cl concentration of EB 08 on 7/01/81 has to be deteted.

The original values for the preliminary corrections that have to be deleted can be recorded on the calculation sheets by rubbing out the correction that was written above the original value.

The data of EB 07 are now fully checked and ready for data presentation.

6. DATA PRESENTATION

After checking and cross-checking of the data following the procedures described in the previous chapter the data are ready for data presentation.

The organisation of the data in the yearbooks will be area-wise. A main report describing the data collection and processing methodology and including a preliminary analysis of the data that are collected should be written. In appendices to this main report the processed field data as well as the calculated average discharge and water quality parameters will be presented.For each subarea (Fayum, Eastern Delta, Middle Delta, and Western Delta) such an appendix should be prepared. For the detailed and monthly presentation the appendix should be organized catchment area-wise.

The detailed data presentation serves users of the yearbooks with scientific intersts as well as the Ministry of Irrigation for its planning of the reuse of drainage water (water quality). The monthly presentation is intended for project planning purposes (Ministry of Irrigation).

The presentation of stage - discharge curves, water quality curves and double mass curves is for internal purpose of DRI mainly. Once available, these relationships may be used to check and cross-check the collected data immediately after field collection. Because it is anticipated that the (empirical) relationships may gradually change with time, it is recommended to use the most recently found relationships for this purpose (i.e. use the relationships of 1980 for the data of 1981.

The following general procedures have to be followed for the data presentation:

1. Prepare a table with measurement results of the data collected during the observation year. Use the corrected data. For measurement dates, for which corrections have been applied to the concentrations of cations and/or anions the SAR, adj. SAR, RSC and TDS have to be calculated using the HP 97 programme 'Water quality data processing'. See chapter 6.1.
2. Prepare a graph of discharge and salinity TDS and a graph of the sodium hazard, SAR and adj. SAR against time using the data of the observation year. See chapter 6.1.
3. Calculate the periods between successive measurements and between measurements and the first day of each month. The HP 97 programme 'Periods' can be used for this purpose. See chapter 6.2.
4. Calculate the interpolated values of discharge and concentration for the first day of each month. The HP 97 programme 'Interpolation' is available for this purpose. See chapter 6.2.
5. Calculate the monthly average values of discharge Q, and cation and anion concentrations using the HP 97 programme 'Monthly average'. Check for each month the average SO_4^{2-} concentration against the concentration calculated as the difference between cations and other anions. If for the calculation of weighted average water quality data the discharge is not available (has not been measured for some period), discharge data from the previous observation year should be used as weights. See chapter 6.2.
6. Calculate the yearly average values of discharge and cation and anion concentrations using the HP 97 programme 'yearly average'. Check the SO_4^{2-} concentration. If for some months no data have been collected on water quality and/or water quantity use data of the previous observation year for the calculation of the yearly average and indicate with an asterix (*)if this has been the case. See chapter 6.3.
7. Record the results on the table with monthly averages. Do not record the data used from the previous observation year either for the calculation of average concentrations, nor for the calculation of the yearly averages. Use the HP 97 programme 'Water quality processing' for the calculation of SAR, adj. SAR, RSC, EC and TDS and record the results in the table.
8. Prepare per catchmant area a table with the yearly average discharge (salinities and cation and anion concentrations. See chapter 6.3.
9. Prepare graphs for the pertinent empirical relationship using the checked observations of the observation year. This includes:
   float - pendulum relation
   - depth - discharge relation
   - EC - Na^+ relation
   - EC - Cl^- relation
   - EC - EC relation
   - depth - depth relation
   - discharge - discharge relation

   Construct the enveloping curves for these relations following the procedures given in chapter 6.5.

6.1. Detailed data presentation

The detailed data presentation will be in tables and in figures. In the tables the following data will be included (see annex 7 for examples):

- measurement date, format dd/mm, where dd is the day number and mm the month number, for open

drains and for pump stations with monthly discharge data. For pump stations where the discharge is known per decade the decade itself may be used instead of the measurement date (see annexes 7.7.1. and .8.1). The decade is indicated with the first three letters of the month and a Roman numeral I, II of III for the first, second and third decade of the month.

- water depth D in m, format D.DD, for open drains. If for pump stations discharges are known per decade and if suction head data have also been collected in this column the average suction head Δ H in m, format H.HH should be presented.
- discharge Q in $m^3.s^{-1}$, format QQQ.QQ. For pump stations where the discharge is known only as the monthly total this column is left open.
- electrical conductivity EC in $mmho.cm^{-1}$, format EE.EE .
- total dissolved solids TDS in ppm ($\equiv mg.l^{-1}$), calculated from the ionic composition of the drainage water, format SSSSO.
- acidity pH, format P.P .
- sodium hazard SAR and adj. SAR in $mmol^{1/2}.l^{-1/2}$, calculated from the ionic composition of the drainage water, format SSS.S.
- residual sodium carbonate RSC in $meq.l^{-1}$ calculated from the ionic composition of the drainage water, format rrr.r.
- concentration of cations and anions, Ca^{2+}, Mg^{2+}, Na^{+}. K^{+}. CO_3^{2-}, HCO_3^{-}, SO_4^{2-} and Cl^{-}, in $meq.l^{-1}$, format ccc.c.

Two figures have to be prepared, one with the discharge Q and the salinity TDS and one with the sodium hazard SAR and adj. SAR. By chosing the scale of these figures conveniently both figures can be presented together on one page A 4 size. The water quality parameters TDS, SAR and adj. SAR can be connected by straight lines in the figures.
For open drains also the discharge measurements can be connected with straight lines. For pump stations the discharge curve takes the form of a block diagramme. See annex 7.6.1, 7.7.1 and 7.7.2 for examples.

The complete procedure for the detailed data presentation is as follows:

1. Record the checked data from the calculation sheets (see annex 6) of depth, discharge, EC, pH, cation and anion concentrations on the table for detailed data presentation according to the required formats. Include the date of observation. Take care of the following points:
   - omit the data of other observation years that may be included on the calculation sheets(see annexes 6.5, 6.6, 6.7 and 6.8 and compare with annexes 7.5.1., 7.6.1, 7.7.1 and 7.8.1 respectively).
   - omit the column with depth and discharge for pump stations if the discharge is known on monthly basis (see annex 7.6.1.).
   - include the decades during which no water quality measurements have been performed for pump stations if the discahrge is known per decade. In this case only the columns with date (indication of the decade), depth and discharge are used (see annexes 7.7.1 and 7.8.1).
   - for pump stations where discharge and suction head are known per decade: fill in the average suction head in the depth column (no examples can be given here).
   - indicate with an asterix (*) if data have been corrected or estimated.
2. For the measuring dates for which corrections in the cation and/or anion concentrations have been applied or dates for which the TDS, SAR, adj. SAR and RSC have not been recorded on the calculation sheets (see for example annex 6.1, measuring dates 23/01/80, 25/07/80 and 17/12/80) calculate these paramaters using the(corrected)concentrations with the HP 97 programme 'Water quality processing' and record the results on the table for detailed data presentation. For the remaining measuring dates the previously (chapter 4.2) calculated parameters TDS, SAR, adj. SAR and RSC values can be taken from the calculation sheets and recorded on the table for detailed data presentation.
3. Prepare the additional information that should accompany the table in the annex. This additional information should include (if applicable) the following items;
   - observation year
   - catchment area
   - name and code of the measurement point
   - water depth - Hm relation (see calculation sheets)
   - pendulum constant C_p used for the final calcylations
   - float constant c'_D used for the final calculations
   - number of calibration measurements used for the calculations
   - Q-D or Q-ΔH calibration relation, if the point can be can be considered fully calibrated (see chapter 4.3.1 and 4.3.2).
4. Copy the table and transfer the original to the typist for typing.
5. Prepare the horizontal and vertical (discharge left vertical axis and TDS right vertical axis) for the discharge and salinity figures. Take for the horizontal axis 12 cm; each cm representing 1 month; each mm representing 3 days. The length of the vertical

axes depends on the maximum value of discharge and that of TDS. Taking the maximum length for the vertical axes 12 cm (2 figures can still be drafted on one A 4 page) and defining the vertical axes graduation for easy plotting as powers of 10 multiplied with 1, 2 or 5, the following steps have to be followed for the axes preparation:

- take the maximum discharge value during the observation year and divide by 12;
- round this value to the nearest higher value of 1, 2 or 5 * 10^n; this is the graduation of the vertical Q-axis;
- divide the maximum discharge by this rounded number; this gives the minimum required length of the vertical discharge scale in cm;
- repeat the above steps for TDS;
- the length of the vertical axes follows now from the maximum of the minimum required lengths for discharge and TDS.

Taking the data in annex 7.1.1. as an example:

- Q_{max} = 4.83; divide by 12 : 0.40
- round off: 0.50; 1 cm represents 0.50 $m^3.s^{-1}$
- divide Q_{max} by 0.50: 9.66; minimum length vertical scale 10 cm
- TDS_{max} = 3290; divide by 12: 274.17
- round off: 500; 1 cm represents 500 ppm
- divide TDS_{max} by 500: 6.58; minimum length vertical scale 7 cm
- length vertical axes: maximum of 10 and 7 cm: 10 cm (see fig. A7-1).

6. Plot the discharge and salinity data in the figure using different symbols for both. Include the last measurement of the preceding observation year and the first measurements of the succeeding observation year (outside the area enclosed by the axes) for interpolation purposes (see next step).
7. Connect the plotted points by straight lines (linear interpolation). Take care of the following points:
   - for pump stations the discharge is assumed to be constant during the period for which discharges are known resulting in block diagrams (see annex 7 for examples);
   - connect the first measurement of the observation year with the last measurement of the previous observation year but stop the line at the Q axis. Then remove the observation of the previous year from the figure. Do the same with the last measurement of the observation year and the first measurement of the next observation year;
   - if during 2 consecutive months, or longer, no measurements have been collected, do not connect the measurements of before and after this period with straight lines (see figs A7-27, A7-33, A7-37 and A7-41 in annex 7).
8. Repeat steps 5,6 and 7 for the sodium hazard figure. Since always the adj. SAR is found greater than the SAR the determination of the length of the vertical axes (SAR left axis and adj. SAR right axis) can be done using the maximum adj. SAR value during the observation year. The graduation of both vertical axes will then be equal.
9. Copy the A4 paper with the two figures and transfer the original to the drawing office.

6.2. Monthly averages

For the calculation of the monthly average it will be assumed that the discharge varies linearly with time between two successive measurements. For the calculation of monthly average concentrations it is assumed that the load of the ion in question varies linearly between successive measurements. The formula for the monthly average discharge is as follows:

$$\bar{Q} = \frac{\sum_{i=1}^{N} \frac{Q_{i+1} + Q_i}{2} P_i}{\sum_{i=1}^{N} P_i} \qquad (6\text{-}1)$$

where:

$\bar{Q}$ = average discharge in $m^3.s^{-1}$

N = number of periods between measurements and interpolations in the month for which the average is calculated

Q_i = measured or interpolated discharge in $m^3.s^{-1}$

P_i = period in days

At pump stations the average monthly discharge is calculated by dividing the total volume of water pumped by the number of days during this month. For pump stations with monthly data this has been done already during the data processing stage. For pump stations with discharge data per decade the average discharge can be calculated as the weighted average of the decade averages and equation (6-1) reduces to:

$$\bar{Q} = \frac{10\,Q_I + Q_{II} + P_{III}Q_{III}}{20 + P_{III}} \qquad (6\text{-}1a)$$

where: Q_I = average discharge in decade I

Q_{II} = average discharge in decade II

Q_{III} = average discharge in decade III

P_{III} = number of days (8, 9, 10 or 11) during decade III

The average concentration is calculated with:

$$\bar{C} = \frac{\sum_{i=1}^{N} \frac{Q_{i+1} C_{i+1} + Q_i C_i}{2} P_i}{\bar{Q} \sum_{i=1}^{N} P_i} \qquad (6\text{-}2)$$

Where:

$\bar{C}$ = average concentration in $meq.l^{-1}$

C_i = measured or interpolated concentration in $meq.l^{-1}$

The pH, being defined as the negative logarithm of the H^+ concentration should be converted to concentration before calculating the average:

$$[H^+] = 10^{-pH} \qquad (6\text{-}3a)$$

and after calculation the average pH is found:

$$\overline{pH} = -\log [\overline{H^+}] \qquad (6\text{-}3b)$$

where: $\overline{pH}$ = average pH value

The interpolated values of discharge and concentrations can be calculated with the equations:

$$Q_I = Q_1 + \frac{Q_2 - Q_1}{P_1 + P_2} P_1 \qquad (6\text{-}4)$$

for discharge, where:

Q_I = interpolated discharge in $m^3.s^{-1}$

Q_1 = last measurement preceding the date for which Q_I is calculated(first day of the month)in $m^3.s^{-1}$

Q_2 = first measurement succeeding the date for which Q_I is calculated in $m^3.s^{-1}$

P_1 = period, in days, between last preceding measurement and first day of the month

P_2 = period, in days, between the first day of the month and the first succeeding measurement

At pump stations the discharge is considered constant during the periods for which discharge data have been collected. For the date of interpolation therefore the interpolated discharge can be approximated by the average of the average discharge of the preceding period and the average discharge of the succeeding period and equation (6-4) reduces to:

$$Q_I = \frac{Q_1 + Q_2}{2} \qquad (6\text{-}4a)$$

For concentrations (linear interpolation of the load) the following formula is valid:

$$C_I = \frac{Q_1 C_1 + \frac{Q_2 C_2 + Q_1 C_1}{P_1 + P_2} P_1}{Q_I} \qquad (6\text{-}5)$$

where:

C_I = interpolated concentration of the ion in question in $meq.l^{-1}$

C_1 and C_2 = concentrations measured during the preceding respectively succeeding data in $meq.l^{-1}$

The calculation of the periods P_i in between two measurement dates can be facilitated by using the Julian Day Number*:

$$J = \text{Int}(365.25\ y') + \text{Int}(30.6001\ m') + d + 1720982 \qquad (6\text{-}6)$$

where:

J = Julian Day Number

Int( ) = integer function; takes the integer of the expression in between brackets

y' = y-1 if m = 1 or 2
y if m > 2

y = year number (A.C.)

m = month number (January = 1, February = 2,etc.)

m' = m + 13 if m = 1 or 2
m + 1 if m > 2

The period length P between two dates can then be calculated as the difference between the two Julian Day Numbers:

$$P = J_2 - J_1 \qquad (6\text{-}7)$$

Three HP 97 programmes have been prepared to facilitate the calculation of the monthly averages.

Equations (6-6) and (6-7) have been programmed for the HP 97 calculator: programme 'periods'. The following subprogrammes (key board controlled) are distinguished (see annex 8.4 for the programme listing and user instructions):

LBL a. In this subprogramme the constants for equation (6-6) are stored (initialization of the main programme).

LBL A. This is the main programme. The measurement date is read, the Julian Day Number calculated, and after the second data entry the period length in days is printed. The input format of the date is as follows: dd.mmyy, where dd is the day number of the month, mm is the monthnumber (01 for January, 02 for February, 03 for March, etc.) and yy is the last two digits of the yearnumber.

Examples: January 22, 1979, input format: 22.0179
November 1, 1982, input format: 1.1182

Due to the input formatting the programme is valid till December 31, 1999 only.

Equations (6-3), (6-4) and (6-5) have been programmed for the HP 97 calculator: programme 'Interpolation'. The following subprogrammes (key board controlled) are distinguished (see annex 8.5 for the programme listing and user instructions):

LBL a. In this subprogramme the period length in days from the last preceding date till the interpolation date P_1 and from the interpolation date till the first succeeding date P_2 are read and stored.

LBL A. This is the main programme for the calculation of the interpolated discharge. The discharges Q_1 and Q_2 are read and stored and the interpolated discharge Q_I is calculated (equation 6-4), stored and printed.

LBL b.In this subprogramme flag 1 is set for the calculation of the interpolated pH value.

LBL B. This is the main programme for the calculation

* The Julian Day Number is an astronomical convention representing the number of days since January 1, 4713 B.C.

of the interpolated concentration according to equation (6-5). The programme tests for the status of flag 1 and if set it will apply equation (6-3a) on the input data (pH) before calculating the interpolated value and equation (6-3b) on the result to convert the H^+ concentration back to pH. The concentrations C_1 and C_2 (or pH_1 and pH_2) are read and the interpolated concentration is calculated and printed.

LBL C. In this subprogramme the interpolated discharge Q_I is stored in the calculator. This subprogramme is used for pump stations; in this case Q_I is calculated by hand according to equation (6-4a) and entered in the calculator after executing LBL A.

The equations (6-1), (6-2) and (6-3) have been programmed for the HP 97 calculator programme 'Monthly average'. The following subprogramms (key board controlled are distinguished (see annex 8.6 for the programme listing and user instructions):

LBL a. In this subprogramme the registers are initialized and the number of periods distinguished in the month for which the averages are calculated is read and stored.

LBL A. In this subprogramme the length of the periods P_i are read and stored in the pertinent registers. A maximum number of 6 periods P_i can be stored.

LBL b. This subprogramme is executed after the main programme for discharge LBL B if the measurement point is a pump station. If discharges are known on a monthly basis, the average monthly discharge is read and stored in the calculator. If discharges are known per decade, the monthly average discharge has to be calculated by hand (equation 6-10), read and stored in the calculator.

LBL B. This is the main programme for calculating the average discharge. The discharge Q_i are read one by one, stored in the registers and the average discharge is calculated according to equation (6-1) and printed.

LBL c. This subprogramme has to be executed before calculating the average pH in LBL C. In this case flag 1 is set as a signal that equation (6-3a) has to be applied before calculating the average and (6-3b) before printing the result.

LBL C. This is the main programme for calculating the average concentration. The concentrations C_i are read one by one, stored in the registers and the average concentration is calculated according to equation (6-2) and the result printed. The programme tests if flag 1 is set and if so (calculation average pH) equation (6-3a) is applied on the input (conversion of pH to concentration) and equation (6-3b) on the output (conversion of concentration to pH).

The complete procedure for the calculation of the monthly average is as follows:

1. Fill in any gaps in the calculation sheet in the discharge column for those dates that no discharge measurements have been made but only water quality measurements. Take (interpolated) data from the previous observation year. In this report this was not possible because 1980 has been the first year of observation. In annex 6.5 for example data on discharges of 1981 have therefore been used.
2. Calculate the periods P_i between measurement dates and between measurement dates and the first day of each month. Start with the last measurement date of the previous observation year and continue until the first measurement date of the next observation year. Record the periods P_i on the calculation sheet in the second column behind the measurement date (see for example annex 6.1). Use for the calculations the HP 97 programme 'Periods' and follow the user instructions given in annex 8.4.
3. Calculate the interpolated Q_I, pH_I and C_I values. Use for the calculations the HP 97 programme 'Interpolation' and follow the user instructions given in annex 8.5. Calculate per interpolation date in the following sequence:
   - discharge Q_I; for pump stations Q_I should be taken as the average of the discharges during the preceding and the succeeding period (eq. 6-4a). Record Q_I on the calculation sheet.
   - acidity pH_I and concentrations of Ca, Mg, Na, K, CO_3, HCO_3 and Cl. Record the results on the calculation sheet.
   - calculate the SO_4 concentration as the difference between cations and anions: Ca + Mg + Na + K - (CO_3 + HCO_3 + Cl). Record the result on the calculation sheet.
   - calculate the interpolated SO_4 concentration using the HP 97 programme and check if the result differs from the SO_4 concentration calculated as the difference between cations and anions. If the difference between both is more than 0.2 meq.l^{-1} a mistake in the data entry in one of the previous calculations can be suspected and the calculations should be repeated.

   Taking the interpolation of data for WE 10 (see annex 6.7) for 01/03/1980 as an example (following the instructions given above and the user instructions for programme 'Interpolation' in annex 8.5):
   - read card with programme 'Interpolation'
   - P_1 = 5; ENTER↑; P_2 = 11; press f A

- Q_1 = 1.86; ENTER; Q_2 = 2.60; press A; prints Q_I = 2.09
- the measurement point is a pump station; therefore equation (6-4a) has to be applied: Q_1 = 1.86; ENTER↑; Q_2 = 1.42; press +; press ↑; displays Q_I = 1.64; press C (to store Q_I); Record Q_I = 1.64 on the calculation sheet
- press f B (for the calculation of pH)
- pH_1 = 6.9; ENTER ↑; pH_2 = 7.7; press B; prints pH_I = 7.0
- Ca_1 = 6.5; ENTER ↑; Ca_2 = 6.8; press B; prints Ca_I = 8.4
- Mg_1 = 11.4; ENTER ↑; Mg_2 = 13.2; press B, prints Mg_I = 15.4
- Na_1 = 44.0; ENTER ↑; Na_2 = 60.0; press B; prints Na_I = 64.0
- K_1 = 0.6; ENTER ↑; K_2 = 1.0; press B; prints K_I = 1.0
- HCO_3 = 5.0; ENTER ↑; HCO_3 = 5.0; press B; prints HCO_3 = 6.4
- Cl_1 = 50.8;ENTER ↑; Cl_2 = 61.4; press B; prints Cl_I = 70.0
- Ca_I = 8.4; ENTER ↑; Mg_I = 15.4; press +; Na_I = 64.0; press +; K_I = 1.0; press +; HCO_3 = 6.4; press −; Cl_I = 70.0; press −; displays SO_4 = 12.4 (SO_4 concentration calculated as difference between cations and anions). Record on the calculation sheet
- SO_4 = 6.7; ENTER ↑; SO_4 = 14.6; press B; prints SO_4 = 12.5. The difference between both interpolated values is 0.1 meq.l^{-1}, indicating that no mistakes have been made with the data entry.

4. Calculate the monthly average discharges Q, pH and concentrations and record the results on the tables for monthly data presentation (see annex 7). Use the HP 97 programme 'Monthly average' and follow the user instructions given in annex 8.6. If for one month no measurements have been performed, only the interpolated values are used for the calculations (see for example the month August for FB 03 and FB 04; compare annexes 7.1.1 and 7.2.1 with 7.1.2 and 7.2.2.). If for two or more consecutive months no data have been collected no data should be recorded in the table for monthly data presentation for these months. Never record data of previous observation years in the tables!
   If for a certain period no discharge data are available, but only water quality data have been collected, the (interpolated) discharge data of the previous observation year can be used as weights for the calculation of average water quality data. Do not record the average discharges calculated in the table in this case!
   The calculations should proceed in the same sequence as discussed in step 3 for the interpolation.
   Taking the calculation of the averages for WE 10 for the month March as an example (input data in annex 6.7; results in annex 7.7.2; following the user instructions for programme 'Monthly average' in annex 8.6):
   - read card with programme 'Monthly average'
   - N (number of intervals) = 3 (see annex 6.7); press f A (initializes programme)
   - P_1 = 11; press A; P_2 = 12; press A; P_3 = 8; press A (storing of P_i in the calculator memory)
   - Q_1 = 1.64 (interpolated value on 01/03; press B; Q_2 = 2.60; press B; Q_3 = 5.64; press B; Q_4 = 5.03 (interpolated value on 01/04); press B; prints $\overline{Q}$ = 3.72
   - WE 10 is a pump station and the $\overline{Q}$ calculated with LBL B is not correct (equation(6-1a) has to be applied instead): 10 ENTER ↑; Q_I = 1.42; press x; 10 ENTER; Q_{II} = 2.60; press x; press +; P_{III} = 11 ENTER; Q_{III} = 5.64; press x; press +; 20 + P_{III} = 31; press ↑; displays $\overline{Q}$ = 3.30; press f B (stores $\overline{Q}$ = 3.30 in the calculator memory)
   - Record $\overline{Q}$ = 3.30 on the table with monthly averages (see annex 7.7.2)
   - press f C (for the calculation of pH)
   - pH_1 = 7.0; press C; pH_2 = 7.7; press C; pH_3 = 7.2; press C; pH_4 = 7.3; press C; prints $\overline{pH}$ = 7.2. Record average pH
   - Ca_1 = 8.4; press C; Ca_2 = 6.8; press C; Ca_3 = 4.5; press C; Ca_4 = 4.5; press C; prints $\overline{Ca}$ = 6.1. Record average Ca
   - continue with the other concentrations except SO_4
   - calculate SO_4 as the difference between cations and anions ($\overline{SO_4}$ = 6.9) and record result (see annex 7.7.2)
   - calculate average SO_4 concentration with HP 97 programme ' Monthly average' ($\overline{SO_4}$ = 6.9) and check the difference.
5. Calculate the SAR, adj. SAR, RSC, EC and TDS using the calculated average concentrations as input with the programme 'Water quality precessing' following the user instractions given in annex 8.3. Record the results in the table for monthly average data presentation.

6.3. Yearly averages

The yearly averages should be reported in the yearbooks in two ways. First, on the tables with monthly averages, the yearly average should be in-

cluded (see annex 7). Second, seperate tables with yearly average values for discharge, salinity and cation and anion concentrations should be prepared for each catchment area.

The yearly averages can be calculated using the monthly averages. For discharge the number of days during each month can be taken as a weighing factor:

$$\bar{Q} = \sum_{i=1}^{12} Q_i P_i / \sum_{i=1}^{12} P_i \qquad (6\text{-}8)$$

where: $\bar{Q}$ = average yearly discharge in $m^3.s^{-1}$

i = month number (i=1 for January; i=2 for February; etc.)

Q_i = average monthly discharge in month i

P_i = number of days during month i

The average concentrations can be calculated using the total monthly discharge volume as weighing factors:

$$\bar{C} = \sum_{i=1}^{12} C_i Q_i P_i / \sum_{i=1}^{12} Q_i P_i \qquad (6\text{-}9)$$

where: $\bar{C}$ = average yearly concentration in $meq.l^{-1}$

C_i = average monthly concentration in $meq.l^{-1}$

For the calculation of yearly average pH equation (6-3) has to be applied as well.

Equation (6-3), (6-8) and (6-9) have been programmed for the HP 97 programme 'Yearly average'. The following (key board controlled) subprogrammes are distinguished (see annex 8.7 for the programme listing and user instructions):

LBL a. In this subprogramme the registers are initialised.

LBL A. This is the main programme for the calculation of average discharge. For each month the period length P_i and discharge Q_i are read and stored in the registers. After reading 12 sets of data the average discharge (eq. 6-8) is calculated and printed.

LBL b. In this subprogramme flag 1 is set. It is only executed before the calculation of average pH.

LBL B. This is the main programme for the calculation of average concentrations. For each month the concentration C_i is read and multiplied with the P_iC_i value that has been stored under LBL A. The programme tests if flag 1 is set, and if so, applies eq. (6-3a) on the input (conversion pH to concentration) after reading the input and eq.(6-3b) before printing the output. After reading 12 C_i values the average concentration (eq. 6-9) is calculated and printed.

The procedure for calculating the averages is as follows:

1. Fill in any gaps in data in the table with monthly average data. Use data of the previous observation year and record them on the table using a pencil (before transferring these tables to the typist these data have to be removed again). In this report this was not possible because 1980 was the first observation year. Data of 1981 have been used instead (this has been the case for annexes 7.5, 7.6, 7.7 and 7.8).
2. Calculate the averages using the HP 97 programme 'Yearly average' following the user instructions given in annex 8.7. Calculate in the following sequence (see also chapter 6.2):
   - calculate the average discharge and record result
   - calculate the average pH, Ca, Mg, Na, HCO_3, Cl and record the results
   - calculate the average SO_4 concentration as the difference between cations and anions and record the result.
   - calculate the average SO_4 concentration using the HP 97 programme and check the difference between both calculations
   - if this difference is more than 0.2 $meq.l^{-1}$ repeat the calculation
   - if data of the previous observation have been used for calculating the averages, indicate this with an asterix (*) in the yearly average data (see annexes 7.5.2. - 7.8.2 for examples)
3. Calculate the SAR, adj. SAR, RSC, EC and TDS using the yearly average concentrations as input with the HP 97 programme 'Water quality processing' following the user instructions given in annex 8.3. Record the results in the table.
4. Rub out the data of the previous observation year that possibly have been used for the calculation of the yearly averages. Copy the table and transfer the original to the typist for typing.
5. After finishing the calculations of all measurement points for a catchment area, prepare a table with average data. No such tables have been given in annex 7, because no complete catchment area has been calculated in this report. In table 6-1 the

Measurement point	Q	TDS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
EH 01										
EH 02										
EH 03										
EH 04										
EH 05										
EH 06										
EH 07										
EH 08										
EH 09										
EH 10										
EH 11	32.97	1530	4.9	5.2	13.6	0.3	0.0	5.2	5.2	13.6
EH 12										
EH 13	46.54	1630	5.2	5.1	15.1	0.3	0.0	4.9	5.9	14.9

Table 6-1. Average discharge and water quality data for the Bahr Hadus catchment area for the observation year 1980

format of such a table is given, including the average data calculated for EH 11 and EH 13 (annexes 7.4 and 7.5).

6.4. Micro elements and nitrogen

For some selected measurement points on a monthly basis nitrogen and micro elements are determined in the DRI laboratory. The presentation of these data should be in tables with the observation date and the concentrations in ppm ($mg.l^{-1}$). The heading of such tables could be as follows:

Date	NH_4	NO_3	Cu	Zn	Fe	Mn	B

Since the function of this type of data is only to signal if the concentration reach dangerous levels, there is no nead for further elaboration.

6.5. Empirical relationships

The empirical relationships that have been used for the data checking procedures (see chapter 5) are also useful to check wether the collected data are within the expected range of variation immediately after data collection (chapter 2) and data elaboration (chapter 4). For this reason these empirical relationships should be included in the yearbooks for data presentation.

The way of presentation will be in plots (figures) of the related parameters with the relation itself and the enveloping curves indicating the range of variation that can be expected.

By limiting the maximum length of the axes for these figures to 12 cm, 2 figures can be presented on 1 A4 page. Defining the axes graduation for easy plotting as powers of 10 multiplied with 1, 2 of 5, the following procedure can be followed for determining the axes graduation to be used (see also step 5, chapter 6.1):

- take the maximum value that has to be plotted and divide by 12
- round this value off to the nearest higher value of 1, 2 or 5 * 10^n. This is the graduation of the axis
- divide the maximum value by this rounded number. This gives the axis length required in cm
- repeat this procedure for the other axis.

Generally (except for the float - pendulum relation) power relations are used to correlate the parameters. If the correlation coefficient of this power relation is less than 0.50, however, a linear relation will be considered.

6.5.1. Discharge relations

Two types of empirical discharge relations are of importance: the float - pendulum relation:

$$\bar{v}_f = c_p \bar{v}_p \qquad (6\text{-}10)$$

and the stage - discharge relation:

$$Q = a D^b \qquad (6\text{-}11)$$

where: $\bar{v}_f$ = average float velocity in the measurement cross-section in $m.s^{-1}$

c_p = pendulum constant

$\bar{v}_p$ = average pendulum meter velocity in the measured reference vertical in $m.s^{-1}$

Q = discharge in $m^3.s^{-1}$

a = discharge coefficient

D = water depth with respect to reference datum in m

b = discharge exponent

The procedure for the presentation of the empirical discharge relations is as follows:

1. Prepare the axes for the $\bar{v}_f - \bar{v}_p$ plot, following the instructions given for the axes preparation (see chapter 6.5). Take $\bar{v}_f$ as the vertical and $\bar{v}_p$ as the horizontal axis.
2. Plot the $(\bar{v}_f, \bar{v}_p)$ data pairs in the figure. Use only the (corrected) data of the observation year.
3. Construct the enveloping curves by drawing straight lines through the origin and through the outer $(\bar{v}_f, \bar{v}_p)$ data pairs in such a way that all data points are enclosed by these lines (See annex 7; figs. A 7-3 and A7-17).
4. Prepare the axes for the Q-D plot, following the instructions for the axes preparation. Take care of a possible shift in the reference datum for water depth (this is the case for example with FB 04). Take Q as the vertical and D as the horizontal axis.
5. Plot the (Q,D) data pairs in the figure. Use only the (corrected) data of the observation year.
6. Calculate the power relation (eq. 6-11) using the standard HP 97 programme 'Curve fitting' (press f E for the power curve option). If the correlation coefficient is less than 0.50, calculate the linear relation (Q = a+b D) using the HP 97 programme (press f B for the linear regression option).
7. Plot the relation found (either power or linear relation) in the figure and construct enveloping curves parallel to the relations in such a way that all data pairs are enclosed by these enveloping curves. Use a french curve for the power relation (see annex 7, fig. A7-4, A 7-9 and A7-18

for examples) and a ruler for the linear relation (see annex 7, fig. A 7-24).

8. Copy the figures and transfer the original to the drawing office.

In table 6-2 a summary of the stage - discharge relations found is presented.

Measurement point	Relation	Regression coefficient a	Regression coefficient b	Correlation coefficient R^2
FB 03	$Q=aD^b$	2.06	1.68	0.96
FB 04	$Q=a(D+0.2)^b$	4.49	1.84	0.87
EB 07	$Q=aD^b$	0.77	3.27	0.62
EH 11	$Q=a+bD$	-69.15	27.28	0.48

Table 6-2. Regression coefficient of the stage - discharge relations presented in annex 7

6.5.2. Water quality relations

Two types of empirical water quality relations are of importance: the EC-Na relation:

$$EC = a_n [Na]^{b_n} \qquad (6\text{-}12)$$

and the EC-Cl relation:

$$EC = a_l [Cl]^{b_l} \qquad (6\text{-}13)$$

where: EC = electrical conductivity in mmho.cm^{-1}

a_n and b_n = regression constants EC-Na relation

[Na] = sodium concentration in meq.l^{-1}

a_l and b_l = regression constants EC-Cl relation

[Cl] = chloride concentration in meq.l^{-1}

The procedure for the presentation of the empirical water quality relations is as follows:

1. Prepare the axes for the EC-Na plot, following the instructions given for the axes preparation. Take EC as the vertical and Na as the horizontal axis.
2. Plot the (EC,Na) data pairs in the figure. Use only the (corrected) data of the observation year.
3. Calculate the power relation (eq.6-12) using the standard HP 97 programme 'Curve fitting' (press f E for the power curve option). If the correlation coefficient is less than 0.50, calculate the linear relation ($EC = a_n + b_n [Na]$) (press f B for the linear regression option).
4. Plot the relation found in the figure and construct the enveloping curves (see annex 7 for examples).
5. Repeat steps 1 - 4 for the (EC, Cl) data pairs.
6. Copy the figures and transfer the original to the drawing office.

In table 6-3 a summary of the water quality relations found is presented.

Measurement point	Relation	Regression coefficient a	Regression coefficient b	Correlation coefficient R^2
FB 03	$EC = a[Na]^b$	0.30	0.76	0.94
FB 03	$EC = a[Cl]^b$	0.32	0.80	0.96
FB 04	$EC = a[Na]^b$	0.25	0.83	0.98
FB 04	$EC = a[Cl]^b$	0.35	0.81	0.98
EB 07	$EC = a+b[Na]$	0.86	0.07	0.40
EB 07	$EC = a+b[Cl]$	0.78	0.10	0.40
EH 11	$EC = a[Na]^b$	0.31	0.79	0.87
EH 11	$EC = a[Cl]^b$	0.55	0.57	0.90
EH 13	$EC = a[Na]^b$	0.38	0.72	0.86
EH 13	$EC = a[Cl]^b$	0.34	0.75	0.92
MG 09	$EC = a[Na]^b$	0.66	0.41	0.70
MG 09	$EC = a[Cl]^b$	0.33	0.72	0.65
WE 10	$EC = a[Na]^b$	0.36	0.72	0.93
WE 10	$EC = a[Cl]^b$	0.26	0.82	0.92
WE 11	$EC = a[Na]^b$	0.40	0.66	0.93
WE 11	$EC = a[Cl]^b$	0.30	0.77	0.97

Table 6-3. Regression coefficients of the water quality relations presented in Annex 7

6.4.3. Double mass relations

Three types of empirical double mass relations are of importance; the D-D relation:

$$D_j = a_d (D_i)^{b_d} \qquad (6\text{-}14)$$

the Q-Q relation:

$$Q_j = a_q (Q_i)^{b_q} \qquad (6\text{-}15)$$

and the EC-EC relation:

$$EC_j = a_e (EC_i)^{b_e} \qquad (6\text{-}16)$$

where:

D_j = water depth of measurement point j in m (including the possible shift in reference datum)

a_d and b_d are regression constants D-D relation

Q_j = discharge of measurement point j in $m^3.s^{-1}$

a_q and b_q are regression constants Q-Q relation

EC_j = electrical conductivity of measurement point j in mmho.cm^{-1}

a_e and b_e are regression constants EC-EC relation

The D-D relation should only be presented if both measurement points are open drainage locations and both exhibit a stage - discharge relation.

The Q-Q relation should not be presented if one or both of the measurement points is an irrigation pump

station (i.e. is pumping from the drainage system into the irrigation system).
The EC-EC relation can always be presented.

The procedure for the presentation of the empirical double mass relations is as follows:

1. Select the two measurement points for which the parameters have to be related according to the sequential list of measurement points given in annex 4.
2. Prepare the axes for the D-D plot, following the instructions given for the axes preparation. Take the D values of the measurement point with the highest identification code number for the vertical axis and those of the lower for the horizontal axis (see annex 7 for examples).
3. Plot the (D_j, D_i) data pairs in the figure. Use only the (corrected) data of the observation year. The data D_j and D_i must be of the same observation date ! A deviation of 1 or 2 days, however, is acceptable (same field trip.
4. Calculate the power relation (eq. 6-14) with the programme 'Curve fitting'. If the correlation coefficient is less than 0.50, calculate the linear ($D_j = a + b\ D_i$).
5. Plot the relation found in the figure and construct the enveloping curves (see annex 7 for examples).
6. Repeat steps 2 - 5 for the (Q,Q) data pairs.
7. Repeat steps 2 - 5 for the(EC,EC) data pairs.
8. Copy the figures and transfer the original to the drawing office.

In table 6-4 a summary of the double mass relations found is presented

Measurement points	Relation	Regression coefficient a	Regression coefficient b	Correlation coefficient R^2
FB 04-FB 03	$(D+0.2)=aD^b$	0.59	1.42	0.74
FB 04-FB 03	$Q = a\ Q^b$	0.44	1.86	0.95
FB 04-FB 03	$EC = a\ EC^b$	1.44	1.09	0.77
EH 13-EH 11	$Q = a+bQ$	42.22	0.20	0.02
EH 13-EH 11	$EC = a\ EC^b$	1.06	1.04	0.83
WE 11-WE 10	$Q = a\ Q^b$	2.30	0.66	0.58
WE 11-WE 10	$EC = a\ EC^b$	0.61	0.82	0.67

Table 6-4. Regression coefficients of the double mass relations presented in annex 7

AYERS, R.S., 1977. Quality of water for irrigation. J. of the Irr. and Dr. Div. Vol. 103, No IR2, p. 135-154.

ELGABALY, M.M., 1981. Some aspects of the reuse of drainage water in Egyptian agriculture. 13 p.

ELGHAMRY, D. and M.M. ABDALLAH, 1977. Reuse of drainage water for irrigation. Panel report 77. III.0.4. Advisory Panel for Land Drainage in Egypt. 35 p.

ELGUINDY, S.M., 1979. Reclamation of a part of Edko Lake with the use of drainage water and canal water (preliminary results). Drainage Research Institute, Cairo, Egypt. 7 p.

——— , and M.H. Amer, 1979. Reuse of drainage water. Part 1. Quality criteria for irrigation water. Drainage Research Institute, Cairo, Egypt. 48 p.

EL QUESY, D.E., 1981. Report of a mission to the Netherlands. Drainage Research Institute, Cairo, Egypt. 9 p.

——— , H.B. Schoonman and H. Meyer, 1981. Calibration measurements in highly turbulent flow. Drainage Research Institute, Cairo, Egypt. 13 p.

——— , ——— and ——— , 1982. Calibration measurements in the Eastern Delta. Drainage Research Institute. Technical Report 17. Cairo, Egypt. 71 p.

HAYES, F.Ch., 1978. Guidance for hydrographic and hydrometric surveys. Delft, Hydraulics laboratory. Publication no. 20. 248 p.

HOFSTEE, J. 1977. Proposals for re-organisation and extension of the set-up, the outfit and the research of the laboratory of the Drainage Research Institute in Cairo, Egypt. Panel Report 77.IV.04. Advisory Panel for Land Drainage in Egypt.18 p.

LAMBIE, J.C., 1978. Measurement of flow. Velocity-area methods. In: HERSCHY, R.W. (Ed) Hydrometry: principles and practices. Wiley Interscience New York. p. 1 - 52.

RICHARDS, L.A. (Ed), 1954. Diagnosis and improvement of saline and alkaline soils. Agriculture Handbook 60. United States Soil Salinity Laboratory. p. 7 - 33.

ROEST, C.W.J., 1982. Reuse of drainage water. Mission report 1. Panel Report 82. X.04. Advisory Panel for Land Drainage in Egypt. 12 p.

——— , 1982. Reuse of drainage water. Mission report 2. Panel report 82.XI.04. Advisory panel for Land Drainage in Egypt. 88 p.

RIJTEMA, P.E., 1981. Reuse of drainage water I. Model analysis. Panel report 81. VIII.0.6. Advisory Panel for Land Drainage in Egypt. Institute for Land and Water Management Research, Wageningen, The Netherlands. 47 p.

RIJTEMA, P.E., 1982. Reuse of drainage water III. Data administration. Evaporation model. Panel report 82. XI.03. Advisory Panel for Land Drainage in Egypt. Institute for Land and Water Management Research, Wageningen, The Netherlands. 24 p.

———,and C.W.J.ROEST,1982. Reuse of drainage water II. Data analysis. Panel report 82.XI.02. Advisory Panel for Land Drainage in Egypt. Institute for Land and Water Management Research, Wageningen,The Netherlands. 52 p.

SCHOONMAN, H.B., 1981. Report of a mission to Egypt. Panel report 81.VIII.01. Advisory Panel for Land Drainage in Egypt. 34 p.

——— , 1981. Report of a mission to Egypt. Panel report 81.VIII.08. Advisory Panel for Land Drainage in Egypt. 10 p.

——— , 1982. Report of a mission to Egypt. Panel report 82.X.05. Advisory Panel for Land Drainage in Egypt. 11 p.

——— , 1983. Report on a mission to Egypt. Panel report 83.XII.02. Advisory Panel for Land Drainage in Egypt. 6 p.

SPIEGEL, M.R., 1961. Theory and problems of statistics. Schaum outline series. Mc.Graw-Hill Book Company. 339 p.

VENTE CHOW, 1959. Open channel hydraulics. Mac Graw-Hill, New York. p. 192 - 211.

VISSER, C., 1979. Report on a visit to the laboratory of the Drainage Research Institute in Cairo, Egypt. Panel report 79.VI.02, Advisory Panel for Land Drainage in Egypt. 12 p.

VOLKER, A. 1979. Reuse of drainage water. Measurement and inventory. Panel report 80.VI.04. Advisory Panel for Land Drainage in Egypt. 30 p.

——— , 1979. Reuse of drainage water. A programme of systematic investigations. Panel report 80.VII. 01. Advisory Panel for Land Drainage in Egypt. 27 p.

——— , 1980. Reuse of drainage water. A pre-panel meeting. Panel report 80.VII.02. Advisory Panel for Land Drainage in Egypt. 16 p.

——— , 1982. Evaluation of the progress in the implementation of the programme of investigations on reuse of drainage water. 5 p.

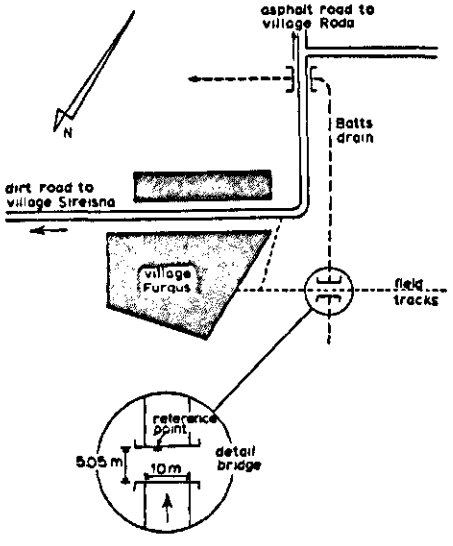
ANNEX 1: FIELD DATA

1. 1. FB 03, Batts drain at Furgus
1. 2. FB 04, Roda drain
1. 3. FB 05, Batts drain at Tamya
1. 4. EB 07, Bahr Bagar drain at "Kubri Saud"
1. 5. EB 08, Bahr Bagar drain at "Kubri Bahr Bagar"
1. 6. EH 02, Hanut pump station
1. 7. EH 11, Bahr Hadus at "Kubri Bahr Bagar"
1. 8. EH 13, Bahr Hadus at "Outfall"
1. 9. MG 09, pump station No. 4
1. 10. MG 10, pump station No. 3
1. 11. WE 10, Edko pump station
1. 12. WE 11, Bosseili pump station

* cross section at measurement location
* float measurements
* pendulum measurements
* waterquality measurements
* calibration measurements

1.1. FB 03, Batts drain at Furgus

The measurement point is a bridge over the drain (see fig. A 1-1)



EC : .....

Hm : .....

distance	1	3	5	7	9
travelling time floats					

Resistance body type: .....

Depth reading	
Angle	

Fig. A 1-1. Situation sketch FB 03 (taken from the field forms)

1.1.1. FB 03, cross-section at measurement location

Distance (m)	Depth				Piers	Level instrument reading	
	Upstream		Downstream				
	no of pieces(m)	excess (cm)	no of pieces(m)	excess (cm)		upstream	downstream
0	3	47	3	37		1,475	1,427
1	4	73	4	81			
2	4	19	4	15			
3	4	03	4	14			
4	4	-	4	14			
5 *	4	05	4	10		1,548	1,512
6	4	05	4	13			
7	4	16	4	15			
8	4	47	4	28			
9	4	97	4	84			
10	3	63	3	44		1,543	1,519

Date observation: 17/09/80
* At Reference point: No of pieces = 4; Excess = 12; and instument reading = 1,546

1.1.2. FB 03. float measurements 1980

Date	Hm	Travelling time floats (sec)				
		1	3	5	7	9
23/12/79	2.48	32.0	11.0	10.5	21.5	pl
9/01/80	2.30	33.4	8.6	9.9	12.1	pl
23/01/80	3.37	-	17.7	20.2	33.6	-
6/02/80	3.42	-	17.0	16.0	26.3	-
24/02/80	2.19	14.0	8.1	8.1	25.3	-
14/03/80	2.72	25.0	9.2	8.0	15.4	-
4/04/80	2.80	11.5	8.0	7.5	11.5	15.0
18/04/80	2.80	12.2	10.0	7.3	13.2	-
30/04/80	2.77	15.0	7.4	7.2	12.0	-
18/05/80	2.85	13.4	8.4	8.0	11.4	15.0
2/06/80	3.03	19.0	11.2	11.2	10.3	21.0
28/06/80	2.94	17.4	8.8	9.0	10.0	-
11/07/80	3.02	28.0	9.0	9.0	17.0	-
25/07/80	2.86	28.0	11.8	9.8	11.6	-
17/09/80	2.50	40.0	14.0	11.4	11.8	14.0
11/10/80	2.66	22.0	11.6	12.4	14.4	-
4/11/80	2.97	17.2	12.0	10.0	18.0	12.8
9/11/80	2.76	25.6	12.6	9.2	17.2	-
17/12/80	2.67	23.2	9.6	9.2	13.0	-
17/01/81	2.72	49.5	9.5	9.0	10.0	-

1.1.3. FB 03, pendulum measurements 1980

Date	Resistance body type	Pendulum measurements, 1st number depth reading C_r (dm); 2nd number angle ∅															
		1		2		3		4		5		6		7		8	
4/04/80	M	(46)	28.5	(44)	24.5	(42)	27.0	(40)	30.0	(39)	30.0	(37)	27.0	-		-	
18/04/80	M	(48)	9.0	(46)	7.5	(44)	7.5	(42)	8.0	(40)	8.5	(38)	8.0	(36)	6.5	-	
30/04/80	L	(42)	16.5	(40)	15.6	(39)	16.0	(38)	16.0	(37)	12.5		-		-	-	
18/05/80	M	(44)	11.0	(42)	7.0	(40)	8.5	(38)	10.5	(37)	9.5		-		-	-	
28/06/80	L	(43)	11.8	(41)	11.8	(39)	12.0	(37)	12.5		-		-		-	-	
11/07/80	L	(45)	10.0	(43)	12.5	(41)	12.5	(40)	10.5	(39)	9.0		-		-	-	
25/07/80	K	(50)	26.5	(48)	27.0	(46)	30.0	(45)	30.0		-		-		-	-	
17/09/80	K	(48)	28.0	(46)	28.0	(44)	27.5	(42)	25.5	(40)	24.5	(38)	24.0		-	-	
11/10/80	K	(41)	25.0	(39)	25.5	(37)	25.5	(35)	27.0	(33)	24.0	(31)	24.0	(29)	22.0	(27)	16.5
4/11/80	K	(46)	26.0	(44)	23.5	(42)	27.0	(40)	26.0	(38)	25.0	(36)	26.0		-		-
9/11/80	K	(49)	22.5	(48)	19.5	(46)	22.5	(44)	23.0	(42)	21.5	(40)	19.5	(39)	20.5		-
17/12/80	M	(46)	8.5	(44)	7.5	(42)	7.5	(40)	6.5	(38)	6.5	(36)	6.0	(34)	5.5		-
17/01/81	L	(43)	15.0	(41)	13.5	(39)	13.0	(37)	11.0	(36)	9.8		-		-		-

1.1.4. FB 03, waterquality measurements 1980

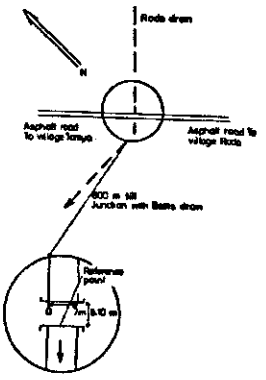
Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79	1.18	8.0	3.1	2.7	5.6	0.3	-	5.5	0.6	5.6
9/01/80	1.45	8.3	3.6	5.3	5.6	0.1	-	4.2	3.3	7.0
23/01/80	3.85	7.4	6.6	10.1	35.0	0.7	-	5.3	17.0	30.1
6/02/80	4.17	7.4	8.5	11.7	28.0	0.7	-	8.8	16.0	24.0
24/02/80	0.94	7.6	2.6	1.4	5.2	0.4	-	3.5	0.8	5.3
14/03/80	1.43	7.8	4.5	3.1	6.5	0.1	-	5.2	2.8	6.2
4/04/80	1.28	7.5	4.0	1.2	7.3	0.3	-	3.5	3.9	5.4
18/04/80	1.45	7.4	3.0	3.2	8.6	0.2	-	4.0	4.0	7.0
30/04/80	1.22	7.6	2.6	2.4	7.0	0.2	-	4.0	2.2	6.0
18/05/80	1.51	8.0	3.0	2.7	9.0	0.3	-	4.0	4.4	6.6
2/06/80	1.24	7.8	3.8	1.4	7.0	0.2	-	4.8	1.0	6.6
28/06/80	1.33	7.3	4.5	1.8	6.7	0.3	-	4.4	3.3	5.6
11/07/80	1.78	7.7	3.6	1.8	13.0	0.2	-	4.1	7.6	6.9
25/07/80	0.98	7.5	3.2	2.4	7.8	0.2	-	2.1	5.7	5.7
17/09/80	1.31	7.6	3.2	1.8	7.7	0.4	-	5.8	1.2	6.1
11/10/80	1.66	7.9	3.7	3.3	9.3	0.2	-	7.0	2.0	7.4
4/11/80	1.68	7.9	3.7	3.3	10.0	0.2	-	7.0	2.7	7.4
9/11/80	1.58	7.8	3.9	2.8	8.7	0.2	-	6.4	3.0	6.2
17/12/80	2.00	7.3	4.2	3.8	11.7	0.4	-	3.4	13.4	3.2
17/01/81	2.37	7.3	4.6	6.3	12.5	0.2	-	4.8	5.1	13.8

1.1.5. FB 03, calibration measurement

Date	Hm	Discharge
17/01/82	3.39	0.51
4/02/82	3.31	1.04

1.2. FB 04, Roda drain

The measurement point is a bridge over the drain (see fig. A 1-2)



EC: .....

Hm: .....

Distance	0.5	1.5	2.5	3.5	4.5	5.5	6.5
travelling time floats							

Fig. A 1-2. Situation sketch FB 04
(taken from the field forms)

1. 2. 1. FB 04, cross section at measurement location

Distance (m)	Depth				Piers	Level instrument reading	
	Upstream		Downstream				
	no of pieces(m)	excess (cm)	no of pieces(m)	excess (cm)		upstream	downstream
0	4	70	4	76		1. 366	1. 368
0. 5	4	10	5	7			
1	5	58	5	56			
1. 5	5	44	5	37			
2	5	44	5	48			
2. 5	5	52	5	46			
3	5	64	5	54			
3. 5	5	60	5	61		1. 376	1. 386
4 *	5	66	5	60			
4. 5	5	52	5	52			
5	5	54	5	48			
5. 5	5	48	5	48			
6	5	50	5	48			
6. 5	5	66	4	28			
7	4	56	4	54		1. 392	1. 360

Date of observation: 17/09/80
* At reference point: No of pieces 5; excess 60 cm; instrument reading 1. 380

1. 2. 2. FB 04, float measurements 1980

Date	Hm	Travelling time floats (sec)						
		0. 5	1. 5	2. 5	3. 5	4. 5	5. 5	6. 5
9/01/80	3. 85	14. 4	7. 6	7. 6	-	6. 6	5. 7	5. 7
23/01/80	4. 39	-	-	10. 8	-	-	17. 0	21. 8
6/02/80	4. 42	-	11. 8	11. 4	-	17. 0	19. 7	-
24/02/80	3. 73	6. 3	5. 2	5. 3	-	5. 1	5. 2	6. 2
14/03/80	3. 96	5. 0	5. 0	6. 0	-	4. 0	5. 2	5. 3
4/04/80	3. 96	-	7. 0	5. 0	-	5. 0	6. 0	6. 5
18/04/80	3. 90	-	4. 8	-	-	5. 0	5. 4	7. 2
30/04/80	3. 89	10. 0	5. 2	-	-	5. 0	5. 0	7. 0
18/05/80	3. 95	5. 6	5. 0	-	-	4. 8	5. 0	5. 0
2/06/80	4. 25	6. 4	6. 3	5. 5	-	-	6. 0	8. 4
28/06/80	4. 20	8. 0	7. 8	-	-	5. 4	6. 8	9. 0
11/07/80	4. 18	-	7. 0	4. 0	-	5. 5	5. 5	9. 0
25/07/80	4. 05	8. 4	5. 8	-	-	5. 4	5. 6	6. 4
17/09/80	3. 45	-	9. 0	-	-	10. 0	8. 4	7. 8
11/10/80	3. 50	15. 0	8. 2	-	-	8. 4	7. 0	8. 6
4/11/80	3. 64	12. 0	7. 0	pl	pl	-	6. 0	8. 0
9/11/80	3. 65	8. 0	7. 4	-	-	7. 2	7. 2	7. 4
17/12/80	3. 47	-	9. 0	-	-	7. 0	7. 5	8. 3
17/01/81	3. 52	-	10. 0	-	-	6. 0	8. 0	9. 0

1. 2. 4. FB 04, water quality measurements 1980

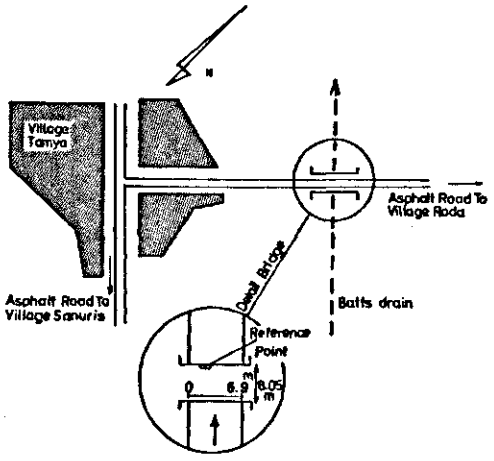
Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
9/01/80	2. 47	8. 4	5. 4	6. 1	13. 0	0. 2	-	4. 7	8. 7	11. 3
23/01/80	8. 42	7. 4	6. 8	23. 1	65. 0	0. 7	-	9. 3	33. 1	53. 1
6/02/80	8. 25	7. 6	14. 8	13. 4	68. 5	0. 6	-	5. 8	40. 2	51. 4
24/02/80	1. 87	7. 6	5. 2	3. 3	10. 2	0. 4	-	4. 4	5. 6	9. 1
14/03/80	2. 13	7. 9	5. 0	6. 9	9. 1	0. 2	-	7. 2	4. 9	9. 1
4/04/80	1. 87	7. 5	5. 0	3. 2	10. 0	0. 4	-	4. 2	7. 2	7. 2
18/04/80	1. 42	7. 4	3. 0	2. 7	8. 3	0. 2	-	4. 0	2. 7	7. 5
30/04/80	1. 44	7. 6	2. 6	1. 9	9. 8	0. 2	-	4. 0	3. 3	7. 2
18/05/80	1. 48	7. 9	3. 0	2. 7	8. 8	0. 2	-	5. 2	1. 0	8. 5
2/06/80	2. 38	7. 9	5. 4	3. 4	14. 6	0. 3	-	5. 6	7. 6	10. 6
28/06/80	2. 72	7. 4	4. 7	4. 5	17. 6	0. 4	-	5. 0	9. 0	13. 2
11/07/80	2. 81	7. 4	4. 2	3. 0	20. 0	0. 4	-	4. 5	10. 2	12. 9
25/07/80	2. 73	7. 4	4. 7	4. 3	16. 2	0. 2	-	4. 4	8. 6	12. 5
17/09/80	2. 28	7. 7	4. 2	2. 8	15. 4	0. 4	-	4. 8	8. 3	9. 7
11/10/80	2. 18	8. 0	5. 8	3. 0	13. 0	0. 2	-	6. 7	6. 1	9. 1
4/11/80	2. 22	8. 0	5. 8	3. 0	13. 5	0. 2	-	6. 7	6. 6	9. 1
9/11/80	2. 27	7. 9	5. 5	3. 5	13. 3	0. 4	-	6. 4	7. 1	9. 1
17/12/80	2. 18	7. 2	3. 2	3. 4	15. 0	0. 4	-	4. 0	14. 2	3. 7
17/01/81	2. 73	7. 2	5. 9	3. 6	22. 0	0. 4	-	4. 8	8. 5	18. 6

1. 2. 5. FB 04, calibration measurements

Date	Hm	Q
17/01/82	4. 40	0. 33

1. 3. FB 05, Batts drain at Tamya

The measurement point is a bridge over the drain (see fig. A 1-3)



EC: .....

Hm: .....

Distance	0. 5	1. 5	2. 5	3. 5	4. 5	5. 5	6. 5
travelling time floats							

Fig. A 1-3. Situation sketch PB 05 (taken from the field forms)

1. 3. 1. FB 05, cross section at measurement location

Distance (m)	Depth				Piers	Level instrument reading	
	Upstream		Downstream			upstream	downstream
	no of pieces(m)	excess (cm)	no of pieces(m)	excess (cm)			
0	4	52	4	53		1. 603	1. 628
0. 5	5	44	5	56			
1	5	36	5	36			
1. 5	5	36	5	30			
2	5	40	5	30			
2. 5	5	38	5	28			
3	5	36	5	28			
3. 5 *	5	36	5	28		1. 502	1. 560
4	5	24	5	18			
4. 5	5	24	5	10			
5	5	22	5	14			
5. 5	5	36	5	32			
6	5	46	5	14			
6. 5	5	48	5	52			
6. 9	4	46	4	52		1. 457	1. 478

Date of observation: 17/09/80
* At reference point: No of pieces 5; excess 23 cm; instrument reading 1. 560

1. 3. 2. FB 05, float measurements 1980

Date	Hm	Travelling time floats (sec)						
		0. 5	1. 5	2. 5	3. 5	4. 5	5. 5	6. 5
23/12/79	3. 48	11. 0	5. 5	5. 5	5. 5	5. 2	5. 0	5. 5
9/01/80	3. 55	10. 0	5. 0	5. 0	5. 0	5. 0	5. 4	5. 8
23/01/80	4. 39	12. 4	9. 8	9. 8	11. 1	11. 6	14. 2	-
6/02/80	4. 50	8. 9	8. 1	9. 2	7. 2	7. 0	9, 6	-
24/02/80	3. 41	5. 2	5. 0	5. 0	5. 0	5. 0	5. 1	6. 3
14/03/80	3. 79	5. 0	5. 0	5. 8	5. 8	5. 8	5. 8	6. 8
4/04/80	3. 72	4. 0	4. 0	3. 5	4. 0	4. 0	4. 5	4. 0
18/04/80	3. 70	6. 0	5. 0	5. 0	5. 0	5. 2	5. 3	5. 8
30/04/80	3. 66	5. 0	5. 0	5. 0	5. 0	5. 2	5. 0	5. 0
18/05/80	3, 89	5. 4	5. 2	5. 0	5. 0	5. 0	5. 0	5. 4
2/06/80	4. 13	5. 6	5. 2	5. 2	5. 2	5. 2	5. 6	6. 3
28/06/80	4. 02	6. 0	5. 8	5. 8	6. 0	6. 0	6. 4	-
11/07/80	4. 02	6. 5	5. 0	5. 0	6. 5	6. 0	7. 0	16. 5
25/07/80	3. 80	7. 4	6. 8	5. 6	6. 4	6. 0	6. 8	8. 2
17/09/80	3. 40	5. 6	5. 0	5. 2	5. 2	6. 2	7. 2	-
11/10/80	3. 48	7. 0	5. 3	5. 2	6. 0	6. 0	7. 0	8. 1
4/11/80	3. 63	7. 0	6. 6	7. 6	7. 0	7. 8	7. 0	7. 4
11/11/80	3. 61	7. 0	5. 4	5. 6	6. 4	7. 0	7. 0	-
17/12/80	3. 42	6. 0	6. 0	6. 5	6. 0	7. 0	7. 5	9. 0
17/01/81	3. 40	6. 0	6. 0	5. 8	6. 2	7. 8	7. 0	10. 0

1. 3. 4. FB 05, waterquality measurements 1980

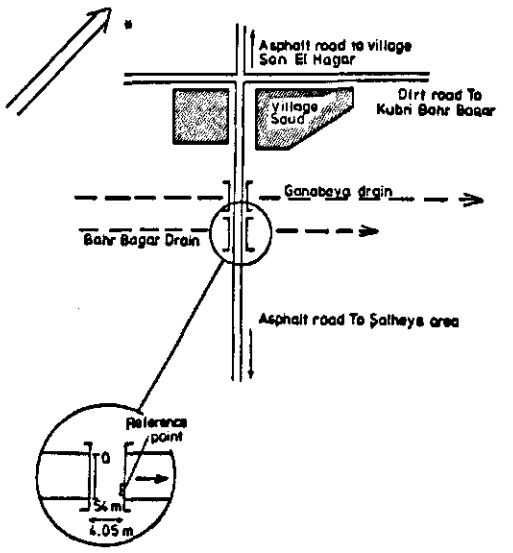
Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79	1. 31	8. 0	4. 0	3. 2	5. 8	0. 2	-	5. 5	1. 7	6. 1
9/01/80	1. 87	8. 6	4. 2	3. 6	10. 6	0. 3	-	5. 1	5. 2	8. 5
23/01/80	5. 70	7. 8	6. 6	13. 7	35. 0	0. 6	-	4. 2	19. 7	32. 0
6/02/80	11. 82	7. 7	12. 7	10. 0	100. 0	0. 3	-	8. 6	78. 5	36. 0
24/02/80	0. 95	7. 1	3. 7	0. 4	5. 5	0. 3	-	2. 3	2. 2	5. 3
14/03/80	1. 96	7. 4	4. 0	5. 5	9. 6	0. 3	-	8. 0	2. 3	9. 1
4/04/80	1. 02	7. 6	3. 5	0. 8	5. 7	0. 3	-	4. 4	2. 0	3. 8
18/04/80	1. 45	7. 4	3. 5	2. 2	8. 6	0. 2	-	4. 0	3. 0	7. 5
30/04/80	1. 29	7. 3	2. 9	2. 6	7. 3	0. 2	-	4. 0	2. 4	6. 6
18/05/80	1. 34	7. 9	3. 5	3. 2	6. 4	0. 2	-	4. 0	1. 7	7. 7
2/06/80	1. 59	8. 0	4. 9	3. 9	6. 8	0. 2	-	4. 4	4. 4	7. 0
28/06/80	2. 04	7. 4	4. 2	3. 6	12. 3	0. 4	-	5. 0	6. 0	9. 4
11/07/80	2. 29	7. 6	3. 1	1. 8	17. 7	0. 3	-	3. 8	9. 5	9. 7
25/07/80	2. 09	7. 8	2. 6	2. 4	11. 0	0. 1	-	4. 8	2. 5	8. 8
17/09/80	1. 91	7. 8	3. 7	2. 3	12. 8	0. 2	-	4. 8	6. 1	8. 2
11/10/80	1. 91	7. 7	3. 7	4. 8	11. 3	0. 2	-	6. 7	5. 6	7. 7
4/11/80	1. 94	7. 7	3. 7	4. 8	12. 0	0. 2	-	6. 7	6. 3	7. 7
9/11/80	2. 00	8. 4	4. 5	3. 0	12. 2	0. 4	-	7. 0	4. 9	8. 2
17/12/80	2. 00	7. 4	3. 7	3. 3	12. 7	0. 4	-	4. 4	12. 0	3. 7
17/01/81	2. 46	7. 2	3. 6	4. 6	16. 0	0. 4	-	5. 0	4. 3	15. 4

1. 3. 5. FB 05, calibration measurements

Date	Hm	Q
14/07/81	3. 97	4. 82
14/01/82	4. 36	2. 55
4/02/82	4. 41	1. 67

1. 4. EB 07, Bahr Bagar drain at "Kubri Saud"

The measurement point is a bridge over the open drain (see fig. A 1-4)



EC: .....

Hm: .....

Fig. A 1-4: Situation sketch EB 07
(taken from the field forms)

Distance	2 '	6 '	10 '	14 '	18 '	22 '	26 '	30 '	34 '	38 '	42 '	46 '	50 '	53 '
travelling time floats														

Resistance bode type: .....

Depth reading	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'
Angle																								

1. 4. 1. EB 07, cross section at measurement location

Distance (m)	Depth				Piers	Level instrument reading	
	Upstream		Downstream				
	no of pieces(m)	excess (cm)	no of pieces(m)	excess (cm)		upstream	downstream
0	2	20	2	46		1. 47	1. 69
2	3	36	3	74		1. 44	1. 70
4	4	92	3	29		1. 44	1. 70
6	4	61	4	78		1. 44	1. 70
8	4	4	4	15	9.20- 9.50	1. 41	1. 70
10	4	15	4	66	10.20-10.50	1. 40	1. 69
12	4	2	4	37		1. 38	1. 70
14	5	85	4	18		1. 38	1. 70
16	5	67	5	86		1. 38	1. 71
18	5	8	5	34	19.30-19.60	1. 38	1. 67
20	4	22	4	87	20.20-20.50	1. 37	1. 55
22	4	15	4	10	20.70-21.00	1. 57	1. 58
24	5	21	4	5	22.80-23.10	1. 34	1. 55
26	5	36	5	52		1. 38	1. 57
28	5	44	5	57		1. 41	1. 61
30	5	30	5	44	31.90-32.20	1. 41	1. 63
32	5	26	5	77	32.45-32.75	1. 42	1. 59
34	5	60	5	55	33.80-34.10	1. 62	1. 60
36	6	66	5	8	34.60-34.90	1. 40	1. 70
38	6	94	6	88	35.15-35.45	1. 44	1. 70
40 *	5	2	6	98	33.70-36.00	1. 46	1. 70
42	5	0	5	7		1. 48	1. 70
44	6	85	5	12	44.10-44.40	1. 48	1. 69
46	5	32	5	46	45.20-45.50	1. 48	1. 69
48	4	17	5	92		1. 51	1. 69
50	4	82	4	84		1. 49	1. 70
52	3	36	3	48		1. 48	1. 70
54	3	86	2	33		1. 46	1. 68

Date of observation: 08/12/80
* At reference point: No of pieces 6; excess 98 cm; instrument reading 1. 70

1. 4. 2. EB 07, float measurements 1980

Date	Hm	Travelling time floats (sec)													
		2	6	10	14	18	2	26	30	34	38	42	46	50	53
20/12/79	1. 75	12. 5	8. 0	8. 2	8. 2	7. 5	7. 2	7. 2	7. 2	12. 3	7. 5	8. 2	8. 7	10. 6	18. 7
6/01/80	1. 98	12. 0	9. 6	8. 2	8. 7	7. 8	8. 9	7. 3	8. 5	15. 8	8. 8	8. 0	9. 9	13. 3	22. 4
27/01/80	2. 10	11. 4	9. 0	7. 4	7. 0	6. 8	7. 5	7. 2	6. 2	-	7. 6	7. 8	8. 8	11. 0	-
10/02/80	2. 28	13. 6	10. 4	-	7. 4	6. 4	-	7. 2	8. 0	-	9. 0	10. 2	11. 2	13. 2	-
25/02/80	1. 97	13. 8	8. 8	7. 2	7. 2	7. 0	6. 8	6. 8	7. 0	-	7. 6	7. 6	8. 3	12. 6	-
9/03/80	2. 06	14. 0	9. 4	7. 0	7. 0	7. 0	7. 0	6. 6	6. 8	-	7. 6	7. 2	8. 2	11. 0	-
23/03/80	2. 11	24. 2	15. 4	11. 0	8. 6	8. 1	-	9. 3	9. 8	10. 2	13. 3	12. 8	10. 8	25. 4	-
13/04/80	2. 18	12. 8	9. 0	7. 6	7. 2	6. 6	7. 0	7. 7	6. 6	7. 7	7. 8	8. 0	9. 6	10. 7	-
20/04/80	2. 21	9. 0	7. 0	6. 0	5. 8	6. 0	5. 5	5. 5	6. 5	6. 9	6. 7	6. 9	7. 0	12. 0	-
4/05/80	2. 21	-	12. 7	10. 6	8. 2	7. 8	7. 5	7. 0	7. 6	-	7. 7	9. 4	11. 5	11. 8	29. 8
26/05/80	2. 14	17. 8	16. 4	8. 8	9. 2	9. 6	8. 0	9. 2	9. 8	9. 0	11. 9	17. 0	11. 4	42. 4	-
3/06/80	2. 12	14. 2	11. 2	7. 8	7. 7	7. 9	7. 2	7. 0	8. 8	8. 0	9. 0	11. 4	10. 3	17. 7	-
15/06/80	2. 16	12. 6	8. 8	7. 2	7. 2	6. 8	6. 2	6. 2	6. 7	7. 2	7. 7	8. 0	8. 4	13. 0	-
29/06/80	2. 14	12. 6	8. 8	8. 6	6. 8	7. 2	6. 4	6. 5	6. 8	7. 6	7. 2	7. 4	8. 3	12. 0	-
16/07/80	2. 07	15. 2	12. 6	8. 0	8. 0	7. 2	6. 0	5. 5	8. 8	6. 8	7. 0	8. 0	-	-	-
31/07/80	1. 94	16. 5	11. 6	8. 0	8. 3	8. 4	-	-	-	-	6. 7	6. 9	8. 8	11. 0	15. 5
18/08/80	-	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl
22/09/80	1. 80	28. 0	15. 5	11. 5	10. 0	8. 5	-	7. 0	7. 5	-	9. 0	9. 5	11. 0	15. 0	43. 0
4/10/80	1. 84	26. 0	15. 0	12. 0	9. 0	8. 0	13. 0	7. 0	7. 0	8. 0	8. 0	7. 4	9. 4	11. 0	17. 4
27/10/80	1. 93	-	47. 0	15. 0	11. 0	8. 0	-	8. 0	7. 0	15. 0	9. 0	15. 0	16. 0	70. 0	78. 0
11/11/80	1. 98	23. 0	12. 0	9. 0	8. 0	7. 0	-	5. 0	5. 0	8. 0	7. 0	7. 0	10. 0	13. 0	-
24/11/80	1. 92	23. 6	15. 2	11. 8	9. 2	9. 2	16. 0	7. 0	7. 0	9. 2	9. 9	12. 0	19. 8	34. 0	-
7/12/80	1. 95	32. 0	13. 6	11. 8	9. 0	7. 8	-	8. 2	8. 8	9. 8	12. 0	12. 6	15. 6	24. 4	-
25/12/80	1. 70	15. 0	11. 4	10. 6	8. 8	7. 6	-	7. 8	7. 8	-	8. 6	8. 9	11. 4	12. 8	21. 6
7/01/81	1. 99	pl	pl	ppl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl

1. 4. 3. EB 07, pendulum measurements 1980

Date	Resist body type	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6
25/02/80	N	19.0	17.5	17.0	16.5	16.0	16.5	15.0	13.5	17.0	15.0	12.0	11.0	10.5	10.0	10.5	10.5	10.0	-
9/03/80	K	24.5	26.0	25.5	29.0	28.5	29.0	28.5	28.5	29.5	28.5	28.5	28.5	28.0	26.0	25.0	26.0	-	-
23/03/80	K	24.5	23.5	24.0	25.0	26.0	29.0	30.0	28.0	29.0	29.0	25.0	27.0	28.0	26.0	26.0	26.0	-	-
13/04/80	K	19.5	16.0	23.0	26.0	27.0	26.0	28.5	28.5	25.5	25.5	25.5	25.0	21.5	24.0	25.5	-	-	-
20/04/80	L	14.5	12.5	12.5	12.0	12.5	12.0	12.5	13.0	11.0	12.0	14.0	12.0	11.0	10.0	15.5	-	-	-
4/05/80	K	26.5	24.0	24.0	24.5	23.0	27.5	27.5	28.0	29.0	28.5	28.5	27.0	26.5	26.0	24.0	26.0	-	-
26/05/80	K	27.0	24.5	24.0	25.5	29.0	29.0	27.5	26.0	27.5	26.0	26.5	25.0	27.0	25.5	26.0	27.5	24.5	-
3/06/80	K	23.0	27.0	28.0	29.0	26.5	27.0	27.0	25.0	25.5	26.0	25.0	25.5	24.5	24.5	24.5	-	-	-
15/06/80	L	17.5	21.0	21.0	22.5	22.5	20.5	21.5	19.5	18.5	18.5	18.5	17.0	15.0	13.5	11.5	-	-	-
29/06/80	L	16.5	19.5	19.0	19.5	19.5	21.5	20.0	19.0	18.5	16.5	15.0	13.5	11.0	11.5	10.5	-	-	-
16/07/80	L	14.0	17.0	20.0	18.5	19.0	19.5	18.5	18.5	16.5	15.0	15.0	14.0	11.5	11.5	10.5	-	-	-
31/07/80	L	15.0	20.0	22.0	21.5	20.0	21.0	20.0	20.0	20.0	18.0	18.5	17.0	16.0	15.0	14.0	12.0	-	-
22/09/80	L	10.5	11.0	13.0	12.5	14.0	12.5	11.5	12.0	12.5	13.0	13.5	11.5	11.5	10.5	9.5	8.5	-	-
4/10/80	L	11.0	13.5	13.5	15.0	15.5	16.0	16.5	16.5	17.0	14.0	15.0	13.5	14.5	11.0	11.5	8.5	7.5	-
27/10/80	L	17.5	10.0	12.0	15.0	15.5	14.0	15.0	16.5	13.0	12.5	8.5	7.5	7.0	7.5	7.5	7.0	6.5	5.5
11/11/80	L	23.0	19.0	18.5	21.5	23.5	25.0	24.0	22.5	22.0	22.0	17.0	19.0	18.0	16.5	14.0	12.0	10.0	-
24/11/80	K	22.5	24.0	25.0	26.0	26.5	28.0	27.0	26.5	28.0	27.0	25.0	24.5	24.0	21.0	20.5	19.5	17.0	15.5
7/12/80	K	12.0	15.5	15.0	17.5	17.0	20.0	16.5	19.0	17.0	18.0	16.0	16.0	15.5	14.5	14.5	14.0	-	-
25/12/80	K	14.5	16.5	17.5	18.0	19.5	20.5	20.0	20.5	17.0	19.5	19.5	19.0	18.5	18.5	18.0	18.0	18.0	19.0
7/01/81	K	18.5	15.5	19.5	22.0	20.0	21.0	23.0	22.5	22.5	21.0	23.0	22.5	22.5	22.5	24.0	22.5	-	-

1. 4. 4. EB 07, waterquality measurements 1980

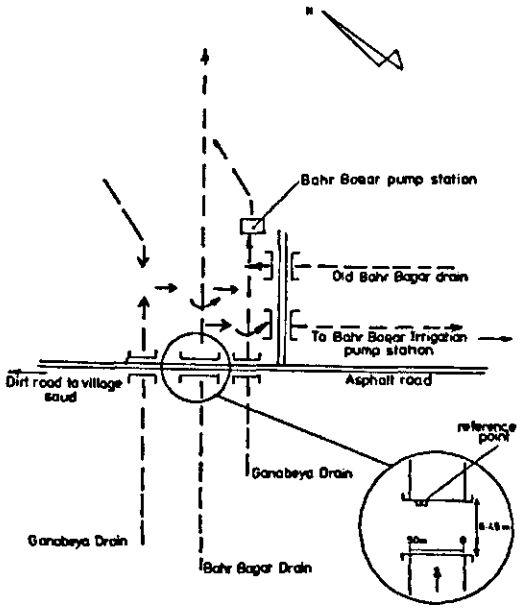
Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79	1. 02	7. 10	4. 40	0. 61	5. 00	0. 25	-	5. 3	0. 88	4. 08
6/01/80	1. 18	7. 15	3. 57	2. 41	5. 40	0. 27	-	5. 09	2. 80	3. 76
27/01/80	1. 46	7. 60	4. 57	3. 82	6. 10	0. 14	-	7. 66	0. 83	6. 11
10/02/80	1. 45	7. 60	4. 73	3. 34	5. 70	0. 23	-	7. 40	1. 32	5. 28
25/02/80	1. 79	7. 15	3. 68	2. 02	12. 00	0. 18	-	4. 90	3. 38	9. 60
9/03/80	1. 17	7. 70	5. 25	5. 25	1. 24	0. 16	-	5. 20	2. 38	4. 32
23/03/80	1. 45	-	3. 68	3. 59	7. 05	0. 18	-	10. 80	0. 11	3. 60
13/04/80	1. 16	7. 50	3. 50	3. 12	5. 10	0. 30	-	1. 16	5. 86	5. 00
20/04/80	1. 12	7. 30	3. 00	2. 70	5. 50	0. 12	-	6. 40	0. 92	4. 00
04/05/80	1. 22	7. 20	3. 15	2. 35	6. 56	0. 14	-	3. 18	4. 02	5. 00
26/05/80	1. 00	7. 40	3. 25	3. 40	3. 00	0. 35	-	5. 60	1. 04	3. 36
3/06/80	1. 07	7. 00	2. 64	3. 54	4. 30	0. 25	-	7. 20	0. 02	3. 50
15/06/80	1. 04	7. 45	4. 44	1. 74	4. 00	0. 22	-	5. 20	0. 50	4. 70
29/06/80	1. 13	7. 45	4. 44	1. 74	4. 00	0. 20	-	5. 20	0. 48	4. 70
16/07/80	1. 20	7. 30	2. 15	1. 85	8. 00	0. 15	-	4. 14	1. 74	6. 27
31/07/80	1. 04	8. 10	3. 40	2. 30	4. 50	0. 16	-	5. 41	0. 79	4. 16
18/08/80	1. 02	8. 60	3. 15	2. 90	4. 00	0. 20	-	5. 30	1. 30	3. 60
22/09/80	1. 06	7. 40	3. 20	2. 40	4. 95	0. 16	-	5. 40	1. 09	4. 14
4/10/80	1. 13	7. 30	3. 67	2. 32	4. 16	1. 15	-	6. 40	1. 30	3. 60
27/10/80	1. 15	7. 30	4. 20	3. 30	3. 10	0. 60	-	5. 00	0. 92	5. 28
11/11/80	1. 16	7. 85	4. 56	2. 66	4. 64	0. 15	-	7. 00	0. 69	4. 32
24/11/80	1. 66	7. 45	4. 60	3. 10	6. 94	2. 00	-	6. 40	6. 03	4. 20
7/12/80	1. 47	7. 30	5. 25	4. 75	4. 70	0. 18	-	7. 00	4. 04	3. 84
25/12/80	1. 40	7. 90	3. 15	3. 02	7. 71	0. 12	-	5. 80	3. 73	4. 47
7/01/81	1. 46	7. 00	2. 46	4. 76	6. 14	1. 24	-	6. 58	4. 26	3. 76

1. 4. 5. EB 07, calibration measurements

Date	Hm	Q
9/09/81	1. 84	37. 24
21/10/81	1. 78	33. 46
26/01/82	1. 95	28. 47

1. 5. EB 08, Bahr Bagar drain at "Kubri Bahr Bagar"

The measurement point is a bridge over the drain (see fig. A 1-5)



Hm: .....

EC: .....

Fig. A 1-5: Situation sketch EB 08
(taken from measurement forms)

Distance	2	6	10	14	18	22	26	30	34	38	42	46	49
travelling time floats													
Resistance body type													
Depth reading													
Angle													

1. 5. 1. EB 08, cross section at measurement location

Distance (m)	Depth				Piers	Level instrument reading	
	Upstream		Downstream				
	no of pieces(m)	excess (cm)	no of pieces(m)	excess (cm)		upstream	downstream
0	3	70	3	69		1. 39	1. 37
2	3	16	3	15		1. 39	1. 38
4	4	81	4	66		1. 40	1. 38
6	4	36	4	13		1. 40	1. 38
8	4	16	5	90	9.60-10.00	1. 40	1. 38
10	5	65	5	80	10.60-11.00	1. 39	1. 38
12	5	65	5	60		1. 39	1. 39
14	5	30	5	20		1. 40	1. 39
16	5	9	6	92	16.40-16.80	1. 39	1. 38
18	5	14	6	95		1. 38	1. 38
20	5	26	5	28	20.40-20.80	1. 38	1. 38
22	6	91	5	7		1. 37	1. 34
24	6	79	6	79		1. 36	1. 34
26	6	70	6	69		1. 34	1. 33
28	6	55	6	84	29.60-30.00	1. 33	1. 31
30	6	70	5	5	31.40-31.80	1. 41	1. 40
32	6	71	6	81		1. 41	1. 40
34 *	6	67	6	73		1. 42	1. 41
36	6	75	6	74		1. 41	1. 41
38	6	83	6	74	39.50-39.90	1. 40	1. 40
40	5	25	5	5	40.60-41.00	1. 40	1. 40
42	5	26	5	21		1. 39	1. 41
44	5	56	5	46		1. 40	1. 40
46	5	91	4	11		1. 40	1. 40
48	4	60	4	60		1. 39	1. 40
50	3	19	3	16		1. 38	1. 37

Date of observation: 08/12/80
* At reference point: No of pieces 6; excess 73; instrument reading 1. 41

1. 5. 2. EB 08, float measurements 1980

Date	Hm	Travelling time floats (sec)												
		2	6	10	14	18	22	26	30	34	38	42	46	49
20/12/79	2. 11	20. 0	16. 7	31. 0	36. 0	13. 7	11. 2	10. 5	12. 5	11. 0	13. 0	14. 5	16. 7	17. 0
6/01/80	2. 31	35. 6	21. 0	21. 6	26. 6	17. 1	13. 0	11. 8	12. 4	11. 4	12. 8	15. 1	14. 9	61. 8
27/01/80	2. 42	22. 0	18. 8	27. 2	32. 0	18. 0	13. 8	11. 4	-	10. 8	12. 6	14. 8	16. 6	-
10/02/80	2. 54	-	18. 2	-	31. 4	16. 0	13. 4	12. 2	-	11. 2	15. 0	15. 0	17. 2	-
25/02/80	2. 33	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl	pl
9/03/80	2. 40	37. 4	18. 0	40. 2	29. 0	16. 0	14. 2	11. 4	-	12. 0	11. 8	15. 0	16. 2	34. 0
23/03/80	2. 34	-	34. 6	37. 2	43. 2	49. 2	29. 0	30. 8	30. 0	19. 0	19. 0	25. 0	30. 8	35. 2
13/04/80	2. 45	40. 0	16. 8	40. 0	-	-	12. 4	11. 0	11. 2	15. 5	11. 7	13. 8	13. 5	17. 8
20/04/80	2. 58	22. 0	14. 5	22. 0	18. 5	12. 0	8. 5	9. 5	-	8. 0	10. 0	10. 0	11. 0	-
4/05/80	2. 82	28. 8	31. 3	-	-	19. 0	15. 7	14. 5	-	17. 0	16. 6	20. 1	23. 4	-
26/05/80	2. 46	-	28. 0	-	-	27. 0	22. 0	15. 8	-	19. 0	26. 1	43. 0	42. 2	-
3/06/80	2. 44	-	29. 8	48. 1	-	30. 4	20. 6	16. 6	-	17. 5	22. 0	22. 2	31. 2	48. 0
15/06/80	2. 50	44. 5	22. 6	-	35. 0	15. 7	11. 4	10. 0	-	11. 2	13. 4	16. 0	19. 6	-
29/06/80	2. 55	-	36. 2	72. 4	73. 5	15. 5	12. 4	11. 0	-	13. 2	15. 0	21. 5	24. 4	-
16/07/80	2. 53	18. 2	11. 8	11. 0	9. 7	9. 0	9. 8	10. 6	16. 8	25. 0	31. 8	19. 3	26. 0	-
31/07/80	2. 44	39. 2	17. 2	48. 0	37. 0	12. 0	9. 6	10. 3	12. 0	8. 4	9. 4	11. 6	14. 7	20. 0
18/08/80	2. 39	22. 8	18. 2	63. 0	27. 4	17. 8	12. 2	10. 0	9. 0	10. 0	11. 2	14. 0	17. 6	21. 6
22/09/80	2. 18	21. 0	18. 5	15. 5	14. 0	13. 0	11. 5	11. 0	19. 0	25. 0	41. 0	34. 0	19. 5	39. 0
4/10/80	2. 22	28. 0	22. 0	38. 0	15. 2	17. 0	12. 6	13. 0	-	12. 0	13. 0	18. 0	22. 0	-
27/10/80	2. 56	120. 0	45. 0	72. 0	-	33. 0	17. 0	14. 0	16. 0	17. 0	25. 0	45. 0	47. 0	59. 0
11/11/80	1. 35	-	19. 0	13. 0	30. 0	22. 0	18. 0	10. 0	10. 0	12. 0	9. 0	10. 0	12. 0	14. 0
24/11/80	2. 30	32. 0	27. 8	35. 0	38. 0	27. 0	16. 2	14. 0	13. 0	13. 0	14. 6	17. 0	20. 6	24. 0
7/12/80	2. 35	48. 0	31. 0	-	32. 6	17. 0	12. 6	13. 0	-	15. 2	19. 0	25. 2	22. 4	81. 4
25/12/80	2. 22	20. 6	17. 4	41. 4	20. 0	11. 4	10. 4	10. 4	12. 0	11. 2	17. 0	14. 8	17. 0	-
10/01/81	2. 24	-	50. 6	58. 8	51. 2	11. 8	14. 0	11. 4	10. 8	11. 8	15. 0	17. 2	20. 2	22. 8

1. 5. 3. EB 08, pendulum measurements 1980

Date	Resist body type	Depth reading, c_p, (dm) (adjusted numbers)																
		40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8
9/03/80	K	19. 5	14. 5	14. 0	17. 5	19. 5	20. 0	19. 5	19. 0	21. 5	20. 0	19. 0	20. 0	18. 0	20. 0	21. 5	-	
23/03/80	K	20. 0	17. 0	15. 0	15. 0	16. 0	16. 0	18. 0	21. 0	22. 0	22. 0	20. 0	19. 0	20. 0	22. 0	20. 0	-	-
13/04/80	K	17. 0	11. 5	14. 0	19. 0	17. 0	15. 0	17. 0	17. 0	17. 5	16. 0	16. 5	16. 0	16. 0	16. 0	16. 0	-	-
20/04/80	K	25. 0	20. 5	20. 0	21. 5	21. 0	25. 5	26. 0	23. 0	25. 0	26. 0	27. 0	23. 5	26. 0	29. 0	-	-	-
4/05/80	K	19. 0	17. 5	20. 0	21. 0	20. 0	20. 0	21. 5	23. 0	23. 0	21. 5	18. 0	16. 5	16. 0	16. 0	19. 0	-	-
26/05/80	K	17. 5	12. 5	12. 5	18. 5	19. 5	19. 5	19. 5	20. 0	20. 0	20. 0	18. 0	18. 5	18. 5	20. 0	-	-	-
3/06/80	K	14. 0	17. 0	17. 0	17. 5	19. 0	19. 0	19. 5	18. 0	19. 5	18. 5	18. 5	18. 0	20. 0	-	-	-	-
15/06/80	K	17. 5	23. 5	23. 0	23. 0	25. 0	24. 0	26. 0	25. 0	26. 0	24. 0	24. 5	20. 0	20. 0	19. 5	-	-	-
29/06/80	K	16. 0	25. 0	24. 0	25. 0	25. 0	25. 0	23. 5	20. 0	22. 0	23. 0	21. 0	21. 0	20. 0	-	-	-	-
16/07/80	L	9. 0	11. 0	12. 0	11. 0	11. 0	10. 0	11. 0	10. 5	8. 5	8. 5	9. 5	11. 0	11. 0	11. 0	-	-	-
31/07/80	L	10. 0	13. 0	12. 5	13. 5	14. 0	14. 5	13. 5	13. 5	13. 5	13. 0	12. 0	12. 5	11. 0	11. 0	-	-	-
18/08/80	K	13. 0	23. 0	23. 0	22. 0	22. 0	25. 0	23. 0	24. 0	24. 0	24. 5	24. 0	20. 0	20. 5	20. 0	-	-	-
22/09/80	L	14. 0	13. 5	12. 0	11. 5	11. 5	12. 5	13. 0	11. 0	11. 0	10. 5	10. 0	9. 5	9. 0	10. 0	9. 0	8. 5	-
4/10/80	L	13. 5	11. 5	15. 0	15. 0	15. 5	16. 0	16. 0	16. 5	17. 0	18. 0	15. 5	14. 0	14. 5	13. 0	12. 5	14. 0	-
27/10/80	K	17. 5	15. 0	11. 5	10. 0	8. 5	7. 0	15. 0	14. 0	15. 0	13. 0	12. 0	13. 0	14. 5	14. 0	10. 0	9. 5	8. 0
11/11/80	L	14. 5	10. 5	8. 5	8. 5	9. 5	9. 0	7. 0	8. 5	8. 0	7. 5	9. 0	9. 0	9. 5	8. 5	7. 5	7. 0	6. 5
24/11/80	K	11. 0	15. 5	19. 0	19. 0	20. 0	20. 5	19. 0	17. 5	20. 5	19. 0	17. 0	17. 5	17. 5	15. 5	13. 5	-	-
7/12/80	K	9. 0	11. 0	13. 0	14. 5	14. 5	15. 0	14. 0	14. 0	15. 0	15. 0	14. 0	14. 0	11. 0	13. 0	-	-	-
25/12/80	K	13. 0	15. 0	18. 0	18. 5	20. 0	20. 5	21. 0	19. 5	18. 5	20. 0	20. 0	19. 5	19. 0	17. 0	19. 0	-	-
7/01/81	K	15. 0	14. 0	18. 5	21. 0	16. 5	20. 0	18. 0	18. 5	15. 5	17. 0	18. 5	19. 5	19. 5	17. 5	22. 0	-	-

1. 5. 4. EB 08, waterquality measurements 1980

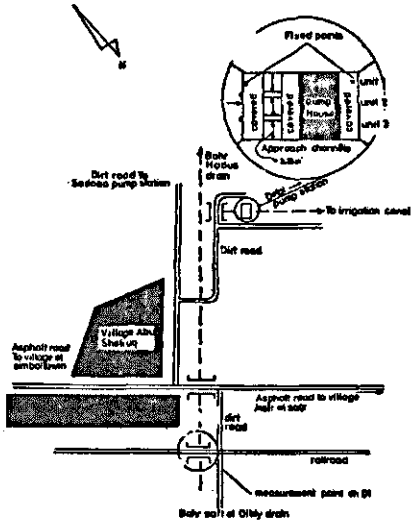
Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79	1. 04	7. 15	4. 95	0. 97	4. 20	0. 25	-	5. 51	0. 28	4. 58
6/01/80	1. 16	7. 10	3. 87	2. 63	4. 50	0. 23	-	6. 63	0. 00	4. 60
27/01/80	2. 21	7. 60	8. 66	8. 10	5. 00	0. 25	-	7. 31	9. 06	5. 64
10/02/80	1. 70	7. 60	5. 25	4. 25	7. 90	0. 23	-	7. 40	3. 51	6. 72
25/02/80	1. 02	7. 00	3. 68	2. 73	3. 50	0. 24	-	5. 20	2. 07	2. 88
9/03/80	1. 14	7. 15	4. 73	3. 77	2. 70	0. 20	-	5. 20	2. 36	3. 84
23/03/80	1. 66	-	5. 25	2. 51	8. 64	0. 20	-	10. 80	2. 20	3. 60
13/04/80	1. 22	7. 20	4. 00	3. 10	5. 30	0. 30	-	1. 20	3. 50	8. 00
20/04/80	1. 16	7. 30	3. 00	3. 65	4. 83	0. 12	-	6. 00	1. 67	4. 00
4/05/80	1. 21	7. 25	3. 67	3. 83	4. 48	0. 12	-	3. 18	3. 92	5. 00
26/05/80	1. 04	7. 40	3. 50	2. 67	3. 70	0. 35	-	5. 60	0. 54	4. 08
3/06/80	1. 10	7. 30	3. 64	3. 00	4. 20	0. 24	-	6. 00	0. 68	4. 40
15/06/80	1. 11	7. 30	3. 61	2. 09	5. 20	0. 20	-	5. 40	1. 00	4. 70
29/06/80	1. 11	7. 30	3. 61	2. 09	5. 30	0. 12	-	5. 40	1. 02	4. 70
16/07/80	1. 13	7. 50	3. 20	0. 80	7. 70	0. 20	-	6. 46	0. 38	5. 06
31/07/80	1. 09	7. 80	3. 94	2. 31	4. 50	0. 20	-	6. 03	0. 50	4. 42
18/08/80	1. 13	7. 10	3. 15	2. 10	4. 10	2. 00	-	5. 42	0. 89	4. 94
22/09/80	1. 11	7. 60	3. 15	2. 85	4. 94	0. 16	-	5. 76	1. 60	4. 14
4/10/80	1. 15	7. 30	4. 20	3. 30	3. 80	0. 20	-	6. 80	0. 65	4. 05
27/10/80	1. 15	7. 40	3. 67	2. 83	5. 10	0. 10	-	6. 10	0. 48	5. 12
11/11/80	1. 18	7. 30	3. 99	4. 61	3. 20	0. 20	-	7. 00	0. 68	4. 32
24/11/80	1. 67	7. 50	5. 41	3. 20	6. 09	2. 15	-	6. 18	5. 90	4. 62
7/12/80	1. 61	7. 10	4. 46	4. 79	7. 30	0. 12	-	6. 00	6. 35	4. 32
25/12/80	1. 55	7. 95	3. 40	3. 26	8. 73	0. 11	-	6. 00	6. 68	2. 82
10/01/81	1. 44	7. 20	1. 82	4. 71	7. 66	0. 21	-	6. 20	4. 67	3. 53

1. 5. 5. EB 08, calibration measurements

Date	Hm	Q
27/09/81	2. 10	43. 63
1/11/81	2. 21	29. 02
7/02/82	2. 48	23. 85

1. 6. EH 02, Hanut pump station

The measurement point is a pumpstation pumping the drainage water of Bahr Saft El Qibly drain into the irrigation system (see fig. A 1-6)



No of pump units in operation: .....

EC: .....

Fig. A 1-6. Situation sketch EH 01 and EH 02 (taken from measurement forms)

1. 6. 5. EH 05, calibration measurements dd. 28/10/81

- level measurements of the fixed points

Instrument location	Beacon location	Instrument reading backward	Instrument reading forward	Remarks
1	a	2. 206		fixed point suction side
1	b		0. 284	
2	b	1. 478		
2	c		1. 040	fixed point delivery side

- water level measurements during calibration

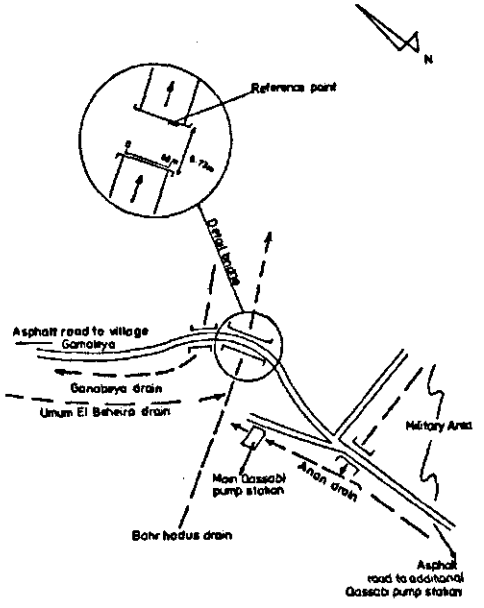
Time	Hm (suction) (m)	Hm (delivery) (m)
10. 00	0. 71	0. 88
10. 15	0. 66	0. 975
10. 30	0. 685	1. 03
10. 45	0. 68	1. 09
11. 00	0. 665	1. 10
11. 15	0. 65	1. 125
11. 30	0. 64	1. 145
11. 45	0. 64	1. 155
12. 00	0. 63	1. 175
12. 15	0. 62	1. 18
12. 30	0. 62	1. 18
12. 32	0. 725	0. 77
12. 45	0. 745	0. 66
13. 00	0. 765	0. 575
13. 15	0. 80	0. 49
13. 30	0. 81	0. 44
13. 45	0. 825	0. 42
14. 00	0. 83	0. 40

- Calibration measurements (number of revolutions per 30 sec.)
OTT Wing number: 1-68827 Width of approach channel: 3. 25 m

Depth from bottom (m)	Distance from approach channel's side (m)						
	0. 125 .	0. 625	1. 125	1. 625	2. 125	2. 625	3. 125
PUMP UNIT 1 : STARTING TIME 10. 00; ENDING TIME 10. 45							
0. 25	60	60	53	52	41	39	41
0. 75	37	37	58	41	38	37	35
1. 25	38	53	51	58	56	51	32
1. 75	51	63	61	52	58	61	30
2. 25	53	62	63	66	60	53	31
2. 75	60	62	54	56	64	51	36
3. 25	47	62	50	59	53	45	25
Total depth(m)	3. 37	3. 38	3. 32	3. 32	3. 35	3. 37	3. 39
PUMP UNIT 1: STARTING TIME 13. 30; ENDING TIME 14. 00							
0. 25	43	43	44	53	59	55	50
0. 75	46	46	51	59	66	65	44
1. 25	45	51	55	58	61	53	46
1. 75	45	50	59	57	60	54	56
2. 25	34	51	51	55	44	44	42
2. 75	35	51	53	46	53	55	57
Total depth(m)	3. 27	3. 27	3. 21	3. 21	3. 24	3. 27	3. 27
PUMP UNIT 1: STARTING TIME 11. 00; ENDING TIME 11. 45							
0. 25	45	59	46	54	44	57	21
0. 75	63	60	55	58	61	65	56
1. 25	58	65	60	53	64	62	50
1. 75	50	44	50	52	61	49	51
2. 25	39	61	63	42	55	53	43
2. 75	44	66	66	55	56	63	53
3. 25	42	55	61	63	58	57	47
Total depth(m)	3. 45	3. 45	3. 45	3. 45	3. 45	3. 45	3. 45
PUMP UNIT 2: STARTING TIME 13. 00; ENDING TIME 13. 30							
0. 25	44	49	52	53	49	58	50
0. 75	58	58	61	61	63	65	45
1. 25	43	57	45	49	54	46	46
1. 75	45	54	59	57	49	60	59
2. 25	41	44	42	55	50	47	49
2. 75	47	55	53	60	59	59	58
Total depth(m)	3. 31	3. 31	3. 31	3. 31	3. 31	3. 31	3. 31
PUMP UNIT 3:STARTING TIME 11. 45; ENDING TIME 12. 30							
0. 25	55	63	62	51	55	60	59
0. 75	55	64	60	56	51	64	44
1. 25	54	66	65	65	66	67	65
1. 75	50	62	67	66	66	61	50
2. 25	51	65	61	64	60	62	46
2. 75	52	65	66	62	52	60	60
3. 25	37	-	-	65	59	54	52
Total depth(m)	3. 27	3. 26	3. 20	3. 30	3. 35	3. 45	3. 45
PUMP UNIT 3: STARTING TIME 12. 35; ENDING TIME 13. 00							
0. 25	54	62	66	44	46	52	42
0. 75	66	69	71	70	63	51	52
1. 25	64	66	67	62	65	62	51
1. 75	55	59	69	61	66	60	51
2. 25	50	58	51	55	58	58	51
2. 75	55	59	42	46	52	57	49
Total depth(m)	3. 10	3. 09	3. 03	3. 13	3. 18	3. 28	3. 28

1. 7. EH 11, Bahr Hadus drain at 'Kubri Bahr Hadus'

The measurement point is a bridge over the drain (see fig. A 1-7)



EC : .....

Hm : .....

Fig. A 1-7. Situation sketch EH 11 (taken from measurement forms)

Distance	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66
Travelling																	
Time floats																	
Depth reading																	
Angle																	

Resistance body type: .....

1. 7. 1. EH 11, cross section at measurement location

Distance (m)	Depth upstream no of pieces(m)	Depth upstream excess (cm)	Depth downstream no of pieces(m)	Depth downstream excess (cm)	Piers	Instrument level reading upstream	Instrument level reading downstream
0	4	91	4	64	1.20- 1.50	0. 90	0. 90
2	4	72	4	61		1. 04	1. 36
4	4	30	4	27		1. 06	1. 33
6	5	87	5	81		1. 08	1. 38
8	5	26	5	23		1. 11	1. 38
10	6	87	6	62	11.70-12.00	1. 11	1. 36
12	6	70	6	22	12.70-13.00	1. 11	1. 31
14	6	34	7	91		1. 10	1. 31
16	7	85	7	75		1. 09	1. 36
18 *	7	60	7	77		1. 08	1. 31
20	7	56	7	85		1. 08	1. 36
22	7	72	6	12	23.00-23.30	1. 32	1. 26
24	7	87	6	33	24.30-24.60	1. 30	1. 29
26	6	1	6	62	25.50-25.80	1. 31	1. 30
28	6	5	6	29	27.30-27.60	1. 22	1. 22
30	7	72	6	25	28.10-28.40	1. 01	1. 25
32	7	51	7	90	29.30-29.60	1. 00	1. 25
34	7	38	7	62		1. 01	1. 24
36	7	69	7	71		1. 03	1. 23
38	6	34	6	19	38.50-38.80	1. 06	1. 24
40	6	17	6	22	39.50-39.80	1. 08	1. 34
42	7	77	6	7		1. 08	1. 29
44	7	63	7	70		1. 09	1. 30
46	7	60	7	73		1. 11	1. 29
48	7	71	7	66	49.70-50.00	1. 12	1. 27
50	6	8	6	10	50.70-51. 00	1. 12	1. 28
52	7	90	6	2		1. 11	1. 28
54	7	91	6	13		1. 11	1. 30
56	6	27	6	17		1. 10	1. 28
58	6	93	6	98		1. 11	1. 32
60	5	53	5	60	61.30-61.60	1. 12	1. 30
62	5	75	4	41	62.30-62.60	1. 11	1. 28
64	5	98	4	41		1. 10	1. 32
66	4	23	4	68	67.30-67.60	1. 10	1. 30
68	4	48	3	27		1. 28	1. 28

Date of observation: 08/12/80

* At reference point: No of pieces 7; excess 77 cm; Instrument reading 1. 31

1. 7.. 2 EH 11, Floats , easurements 1980

Date	Hm	Travelling time floats (sec)																	
		2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	60	66	
20/12/79	2. 37	14. 4	9. 6	9. 6	8. 7	9. 8	9. 2	-	9. 0	9. 2	9. 5	9. 4	9. 0	9. 2	9. 0	9. 4	14. 0	12. 8	
6/01/80	2. 52	29. 2	15. 3	12. 5	12. 3	12. 4	12. 9	-	12. 9	12. 5	12. 5	12. 1	12. 3	11. 6	11. 8	12. 1	13. 8	-	
27/01/80	2. 77	29. 6	18. 6	18. 6	23. 8	15. 8	13. 9	-	14. 8	13. 4	-	14. 0	13. 4	-	15. 6	14. 4	-	-	
10/02/80	2. 76	52. 6	29. 6	-	23. 0	18. 0	-	-	18. 0	17. 2	-	17. 6	22. 2	-	24. 8	22. 0	-	-	
25/02/80	2. 38	13. 0	10. 0	9. 2	8. 0	7. 4	-	-	8. 6	7. 2	6. 2	6. 6	6. 2	6. 0	5. 6	7. 0	-	-	
9/03/80	2. 48	26. 4	11. 0	10. 7	10. 2	10. 4	-	-	11. 0	10. 4	10. 7	9. 4	9. 0	-	8. 3	9. 5	-	-	
23/03/80	2. 66	37. 0	14. 2	12. 8	12. 6	11. 6	-	-	9. 8	10. 6	11. 0	11. 0	9. 0	9. 7	9. 0	11. 6	18. 4	-	
13/04/80	2. 51	18. 0	9. 0	10. 0	9. 2	9. 6	-	-	10. 2	10. 0	10. 8	9. 0	8. 7	8. 2	8. 4	7. 0	9. 2	11. 6	
20/04/80	2. 52	18. 0	14. 0	13. 6	11. 0	9. 9	-	-	9. 9	10. 4	10. 1	9. 8	8. 6	8. 8	8. 6	8. 5	11. 0	17. 0	
4/05/80	2. 63	45. 6	27. 0	25. 0	20. 8	21. 6	-	-	14. 3	15. 5	13. 4	12. 4	10. 4	10. 4	12. 4	19. 2	18. 2	-	
26/05/80	2. 53	30. 2	22. 6	14. 5	13. 8	14. 6	-	-	10. 0	9. 5	7. 6	9. 4	9. 6	9. 0	9. 4	9. 9	-	-	
3/06/80	2. 61	24. 0	16. 0	15. 2	14. 8	14. 8	15. 5	-	12. 4	12. 6	10. 6	12. 2	11. 0	10. 0	10. 8	11. 4	12. 6	-	
15/06/80	2. 49	17. 0	13. 5	12. 6	10. 2	9. 7	8. 0	-	8. 4	9. 2	9. 0	8. 9	9. 5	7. 5	8. 5	9. 0	12. 6	16. 7	
29/06/80	2. 67	51. 9	20. 3	17. 2	15. 2	15. 0	19. 7	-	16. 3	16. 4	15. 0	15. 8	16. 0	15. 8	14. 3	17. 2	29. 0	35. 8	
16/07/80	2. 35	23. 8	13. 4	9. 8	10. 0	9. 2	-	-	8. 5	8. 4	9. 7	7. 5	7. 2	6. 3	7. 2	7. 4	-	-	
31/07/80	2. 30	30. 0	12. 0	11. 3	10. 0	8. 7	7. 6	-	8. 7	7. 8	10. 2	8. 6	8. 0	8. 2	7. 5	8. 7	-	-	
18/08/80	2. 33	28. 2	14. 7	12. 0	12. 0	11. 0	-	-	10. 2	8. 8	9. 0	9. 4	9. 5	9. 5	9. 5	9. 7	11. 7	13. 8	
22/09/80	2. 14	51. 0	16. 5	13. 0	10. 0	10. 0	13. 0	-	10. 0	10. 0	11. 5	10. 0	10. 5	22. 0	8. 0	9. 0	10. 0	11. 0	
4/10/80	2. 90	30. 0	14. 0	10. 0	9. 0	8. 8	11. 0	-	7. 4	8. 6	14. 0	8. 0	6. 0	7. 6	7. 8	14. 0	9. 0	-	
27/10/80	2. 46	17. 0	12. 0	11. 0	10. 0	11. 0	-	12. 0	12. 0	11. 0	10. 0	9. 0	10. 0	10. 0	11. 0	-	-	-	
11/11/80	2. 36	-	18. 0	19. 0	20. 0	17. 0	19. 2	18. 6	18. 0	15. 0	14. 0	12. 0	12. 0	17. 0	12. 0	12. 5	20. 0	30. 0	
24/11/80	2. 30	-	17. 0	13. 4	17. 0	12. 6	-	-	10. 8	12. 0	14. 8	13. 0	12. 0	20. 0	11. 0	11. 0	-	-	
7/12/80	2. 43	35. 6	23. 0	23. 0	17. 0	14. 2	-	-	13. 2	14. 0	14. 6	14. 4	14. 0	13. 2	15. 4	17. 6	19. 2	22. 0	
25/12/80	2. 35	20. 0	14. 0	-	13. 4	12. 4	-	-	11. 0	10. 8	-	11. 6	10. 0	10. 4	10. 4	13. 0	14. 6	18. 0	
7/01/81	2. 03	28. 6	19. 0	13. 2	14. 2	10. 8	9. 8	-	11. 2	11. 8	11. 2	10. 0	9. 6	9. 6	10. 2	10. 0	10. 8	-	

1. 7. 3. EH 11, pendulum measurements 1980

Date	Resist body type	Depth reading, c_T, (dm) (adjusted numbers)																					
		50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6
25/02/80	N	15. 5	12. 5	13. 0	18. 5	24. 5	24. 0	22. 5	25. 0	23. 0	22. 5	21. 0	21. 0	21. 0	20. 5	20. 0	20. 0	18. 5	19. 0	-	-	-	-	-
9/03/80	K	22. 5	22. 0	22. 0	24. 0	23. 5	24. 0	23. 5	23. 5	24. 0	25. 0	25. 5	26. 5	24. 0	24. 0	24. 5	25. 5	27. 0	24. 5	25. 5	24. 0	24. 5	-	-
23/03/80	K	17. 0	16. 5	16. 0	15. 5	15. 0	15. 5	19. 5	20. 0	20. 5	20. 0	22. 0	22. 0	23. 0	21. 0	23. 0	21. 0	-	-	-	-	-	-	-
13/04/80	K	21. 0	19. 5	18. 0	17. 0	14. 0	15. 0	29. 0	29. 5	29. 5	29. 0	28. 5	29. 5	27. 5	28. 5	27. 0	26. 0	27. 0	-	-	-	-	-	-
20/04/80	K	23. 5	21. 5	20. 5	20. 0	20. 0	19. 5	19. 0	27. 0	27. 0	27. 0	25. 0	27. 0	25. 0	25. 0	24. 5	23. 0	27. 0	-	-	-	-	-	-
4/05/80	K	16. 5	14. 0	11. 0	17. 5	17. 5	24. 0	23. 0	22. 0	21. 5	20. 0	20. 5	19. 0	20. 0	23. 0	23. 5	-	-	-	-	-	-	-	-
26/05/80	L	8. 5	7. 5	13. 0	17. 5	17. 0	17. 0	18. 0	17. 5	17. 0	16. 0	15. 5	14. 0	15. 0	13. 5	13. 0	12. 5	-	-	-	-	-	-	-
3/06/80	K	8. 0	16. 0	17. 5	19. 0	20. 0	21. 0	20. 0	21. 0	21. 5	20. 5	21. 0	19. 5	-	-	-	-	-	-	-	-	-	-	-
15/06/80	L	9. 5	16. 5	17. 0	17. 5	17. 0	16. 5	15. 5	14. 5	14. 0	14. 0	14. 5	12. 0	11. 5	12. 0	11. 0	9. 0	-	-	-	-	-	-	-
29/06/80	K	3. 5	6. 5	7. 5	9. 5	10. 0	10. 0	10. 0	7. 5	7. 5	8. 0	8. 5	9. 0	8. 5	8. 5	-	-	-	-	-	-	-	-	-
16/07/80	K	13. 0	29. 5	29. 5	29. 0	28. 5	28. 0	28. 5	28. 5	27. 0	26. 0	27. 0	26. 5	26. 5	26. 5	26. 0	27. 5	-	-	-	-	-	-	-
31/07/80	L	7. 5	16. 0	16. 5	16. 5	15. 5	15. 0	14. 5	13. 5	13. 0	13. 0	13. 0	12. 5	12. 5	12. 0	11. 0	10. 5	9. 5	-	-	-	-	-	-
18/08/80	K	7. 0	10. 5	20. 0	21. 0	22. 0	23. 0	23. 5	25. 0	25. 0	25. 5	25. 5	25. 0	24. 0	23. 0	22. 5	21. 5	21. 5	-	-	-	-	-	-
22/09/80	K	22. 0	21. 0	25. 0	25. 0	27. 0	24. 0	25. 0	25. 0	26. 0	24. 0	26. 0	26. 0	28. 0	27. 0	27. 0	27. 0	26. 0	25. 0	26. 0	25. 0	26. 0	27. 0	26. 5
4/10/80	K	17. 5	17. 5	17. 5	18. 0	18. 0	21. 5	20. 5	20. 5	21. 0	21. 5	22. 0	21. 5	21. 5	21. 0	21. 0	19. 5	19. 5	19. 5	19. 0	18. 5	18. 0	20. 0	-
27/10/80	K	16. 0	16. 0	16. 0	15. 0	14. 0	14. 5	15. 5	16. 5	15. 5	16. 0	15. 0	19. 0	17. 0	19. 5	18. 0	18. 5	18. 5	18. 0	19. 0	-	-	-	-
11/11/80	L	10. 5	7. 0	6. 0	5. 5	5. 0	6. 0	5. 5	5. 0	4. 5	6. 0	5. 5	5. 5	5. 5	4. 0	5. 0	5. 5	5. 0	5. 0	5. 0	5. 5	6. 0	-	-
7/12/80	K	11. 5	13. 0	14. 0	14. 5	12. 0	12. 0	13. 0	13. 5	14. 0	14. 0	14. 0	12. 5	11. 5	12. 5	13. 5	12. 0	11. 5	11. 5	15. 0	-	-	-	-
25/12/80	K	12. 5	11. 5	12. 5	13. 0	12. 0	12. 0	12. 5	11. 5	12. 5	12. 5	12. 0	12. 5	11. 5	13. 0	11. 0	11. 0	10. 0	12. 5	12. 5	13. 0	-	-	-
7/01/81	K	1. 0	2. 0	3. 5	5. 0	5. 5	6. 5	8. 0	9. 0	9. 0	9. 5	9. 5	9. 5	10. 0	10. 5	10. 5	11. 0	15. 0	-	-	-	-	-	-

1. 7. 4. EH 11, water quality measurements 1980

Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79	1. 57	7. 4	5. 5	2. 2	7. 7	0. 2	-	3. 6	0. 3	11. 7
6/01/80	2. 52	7. 4	4. 2	7. 0	13. 7	0. 2	-	4. 2	4. 9	16. 0
27/01/80	3. 83	7. 5	9. 5	8. 6	20. 9	0. 2	-	5. 1	6. 0	27. 3
10/02/80	4. 51	7. 65	8. 93	10. 76	25. 0	0. 21	-	6. 2	7. 41	31. 2
25/02/80	0. 99	7. 25	3. 78	2. 5	3. 4	0. 22	-	3. 8	2. 74	3. 36
9/03/80	1. 87	7. 7	5. 2	6. 8	6. 5	0. 2	-	3. 6	6. 6	8. 5
23/03/80	2. 31	-	5. 2	6. 4	11. 2	0. 2	-	8. 0	0. 2	14. 8
13/04/80	2. 21	7. 45	5. 0	4. 5	13. 0	0. 3	-	9. 2	0. 1	13. 5
20/04/80	2. 30	7. 7	4. 5	4. 5	13. 0	0. 2	-	4. 4	7. 1	11. 5
4/05/80	2. 50	7. 4	4. 7	5. 3	14. 8	0. 2	-	2. 3	8. 2	14. 5
26/05/80	1. 60	7. 6	5. 0	2. 6	8. 3	0. 1	-	4. 4	2. 0	9. 6
3/06/80	2. 22	7. 3	3. 6	8. 0	11. 0	0. 2	-	8. 8	2. 9	11. 2
15/06/80	2. 38	7. 4	4. 4	4. 4	14. 8	0. 2	-	5. 6	3. 2	15. 0
29/06/80	2. 09	7. 4	3. 4	3. 4	15. 7	0. 4	-	5. 6	0. 3	15. 0
16/07/80	2. 55	7. 2	3. 14	4. 86	17. 0	0. 5	-	4. 75	6. 03	14. 72
31/07/80	2. 55	7. 8	4. 7	4. 8	15. 5	0. 2	-	5. 4	5. 8	14. 0
18/08/80	2. 55	7. 4	5. 0	4. 5	14. 8	1. 1	-	5. 3	5. 8	14. 3
22/09/80	2. 46	7. 6	4. 7	4. 8	15. 0	0. 1	-	4. 5	5. 8	14. 3
4/10/80	2. 18	7. 45	5. 3	4. 8	11. 6	0. 2	-	5. 4	6. 5	9. 9
27/10/80	2. 09	7. 85	5. 3	3. 8	11. 8	0. 1	-	6. 7	2. 9	11. 3
11/11/80	2. 28	7. 9	5. 4	5. 7	11. 7	0. 2	-	7. 6	3. 4	12. 0
24/11/80	2. 73	7. 5	6. 8	2. 3	6. 2	0. 2	-	4. 6	3. 09	20. 0
7/12/80	2. 73	7. 3	5. 78	9. 22	13. 0	0. 25	-	4. 0	11. 77	12. 48
25/12/80	2. 18	8. 2	3. 9	5. 6	12. 3	0. 2	-	4. 2	13. 1	4. 7
7/01/81	2. 18	7. 5	1. 82	9. 49	10. 21	0. 28	-	4. 32	10. 29	7. 29

1. 7. 5. EH, calibration measurements

The location for calibration measurements has been chosen ± 20 m downstreams of the bridge (see fig. A 1-7)

- Calibration measurement dd. 8/11/80 (number of revolutions)
  OTT nr. 1-68838; Starting time 12. 30; Ending time 14. 30; measurement interval 25. 6 sec.
  Hm at 12. 30: 2. 52; Hm at 14. 30: 2. 52
  Waterlevel is zero at 0 m. and at 69 m from left bank facing the bridge

Distance from left bank facing the bridge (m)

5		9		13		17		21		25		29		33		37		41		45		49		53		57		61		65		66	
D*	N*	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
130	14	240	15	269	17	260	18	267	24	264	20	263	30	284	24	269	26	218	9	245	10	304	20	320	21	253	10	164	17	100	4	63	1
93	17	225	20	225	25	225	21	225	25	225	27	225	30	275	25	225	27	175	11	225	12	275	27	275	27	225	14	117	24	71	20	45	7
56	25	175	27	175	27	175	17	175	33	175	28	175	18	225	35	175	26	125	9	175	7	225	32	225	33	175	17	70	27	43	18	27	1
19	23	125	28	125	28	125	19	125	31	125	30	125	15	175	36	125	25	75	7	125	6	175	32	175	31	125	16	23	31	14	15	9	6
		75	29	75	33	75	28	75	33	75	34	75	20	125	36	75	25	25	10	75	6	125	34	125	31	75	16						
		25	28	25	32	25	28	25	34	25	37	25	19	75	35	25	29			25	5	75	35	75	31	25	12						
														25	34							25	25	25	34								

* Depth of measurement (cm), read from the depth counter at the reel

- Calibration measurement dd. 2/02/82 (number of revolutions)
  OTT nr. 1-68827; Starting time 13. 30; Ending time 15. 30; measurement interval 26. 2 sec.
  Hm at 13. 30: 2. 78; Hm at 15. 30: 2. 79
  Waterlevel is zero at 0 m and at 62 m from left bank facing the bridge

Distance from the left bank facing the bridge (m)

1		5		9		13		17		21		25		29		33		37		41		45		49		53		57		61	
D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
35	-	160	4	244	9	241	10	245	12	241	11	243	9	268	3	263	1	210	-	220	1	303	-	287	2	210	-	119	2	56	8
25	-	114	8	225	12	225	9	225	11	225	7	225	9	225	4	225	3	175	2	175	3	275	1	275	2	175	2	85	10	40	8
15	-	68	6	175	12	175	11	175	11	175	10	175	8	175	8	175	4	125	7	125	4	225	2	225	8	125	3	51	13	24	9
5	-	22	6	125	11	125	12	125	11	125	13	125	6	125	9	125	4	75	9	75	6	175	6	175	12	75	3	17	14	8	10
				75	11	75	11	75	11	75	12	75	12	75	17	75	14	25	6	25	7	125	9	125	16	25	2				
				25	11	25	11	25	11	25	12	25	19	25	25	25	20					75	11	75	20						
																						25	14	25	24						

- Pendulum measurements

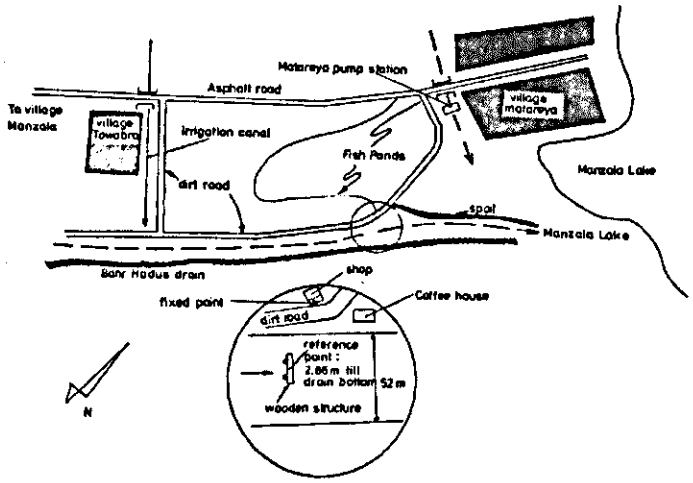
Date	Time	Resist body																	
9/11/81	13.00		depth reading	63	62	60	58	56	54	52	50	48	46	44	42	40	38	36	
Hm = 2. 52			Angle	10. 5	7. 0	5. 0	. 5	7. 5	8. 5	13. 0	13. 0	14. 0	13. 0	15. 0	13. 0	15. 5	15. 5	15. 0	
8/11/81	14.00		depth reading	63	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32
Hm = 2. 52			Angle	11. 0	7. 0	5. 0	6. 0	8. 5	7. 5	13. 0	13. 0	14. 0	13. 0	14. 0	13. 0	15. 0	13. 0	15. 5	15. 5	15. 0
2/02/82	14.00	K	depth reading	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	
Hm = 2. 78			Angle	1, 0	0. 5	0. 5	1. 0	1. 5	2. 5	2. 0	2. 5	2. 5	2. 0	2. 0	2. 0	1. 5	2. 0	2. 5	3. 0	
2/02/82	15.00	K	depth reading	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	
Hm = 2. 79			Angle	1. 0	1. 5	1. 5	2. 0	2. 5	2. 5	2. 5	2. 5	2. 0	2. 5	2. 0	2. 0	2. 5	3. 0	2. 5	3. 0	

- Float measurements (travelling time floats in sec)

Date	Time	Hm	Distance (m)																
			2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66
8/11/81	14.45	2. 52	42. 0	21. 4	19. 2	19. 0	18. 4	18. 8	15. 0	15. 9	17. 4	17. 4	-	-	18. 2	16. 0	35. 0	65. 4	-
2/02/82	16.00	2. 79	-	20. 4	18. 6	132. 0	23. 6	21. 4	-	22. 6	21. 0	20. 0	25. 0	22. 6	29. 8	21. 4	25. 5	-	-

1. 8. EH 13, Bahr Hadus drain at "outfall"

The measurement point is an open drain, with a simple wooden structure for pendulum and water level measurement (see fig. A 1-8)



EC : .....

Hm : .....

Fig. A 1-8: Situation sketch EH 13
(Taken from measurement forms)

Resistance body type: .....

Depth reading																				
Angle																				

1. 8. 3. EH 13, pendulum measurements 1980

Date	Hm	Resist body type	Depth reading, c_r, dm (adjusted numbers)																	
			40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4
6/08/80	0.54	K	3.5	4.0	4.5	5.5	5.0	6.5	7.0	6.0	5.5	6.5	5.0	5.5	4.5	8.5	2.5	1.0	-	-	-
18/08/80	0.55	K	2.0	3.5	4.5	4.5	4.5	4.5	5.0	5.0	5.5	5.0	4.5	4.5	3.0	1.5	1.5	1.0	-	-	-
22/09/80	-	K	3.5	3.5	4.0	3.5	3.5	3.5	3.0	3.0	3.5	3.5	4.0	3.5	4.0	3.5	3.5	-	-	-	-
4/10/80	-	K	4.0	6.0	5.5	6.0	6.5	7.5	7.5	6.5	6.0	7.5	7.0	4.5	5.0	5.5	5.0	4.5	4.0	-	-
27/10/80	-	K	2.0	3.0	3.0	4.0	5.0	4.5	5.5	5.5	6.0	6.0	6.5	6.5	7.0	7.5	7.0	6.0	7.5	7.0	4.5
11/11/80	-	K	10.0	3.0	2.5	2.5	2.5	2.0	2.5	2.5	4.0	8.0	4.0	3.5	4.0	3.5	3.0	2.5	3.5	1.0	-
24/11/80	-	K	3.5	4.0	5.5	5.5	4.0	3.5	3.5	3.5	4.5	4.0	4.0	3.0	3.0	3.5	3.5	2.5	2.5	2.0	1.5
7/12/80	-	K	2.0	2.0	3.0	3.0	2.5	1.5	1.0	1.5	1.5	3.0	2.5	2.0	2.5	3.0	2.0	1.5	1.5	-	-
25/12/80	-	K	3.0	3.5	3.5	5.0	4.0	5.5	5.0	6.0	6.0	6.5	5.5	5.5	4.5	4.5	3.0	4.0	4.5	4.5	-
7/01/81	-	K	1.5	2.0	2.0	1.5	1.5	2.5	1.5	2.0	1.0	1.5	2.0	1.5	3.5	3.0	3.0	2.0	5.5	-	-

1. 8. 4. EH 13, waterquality measurements 1980

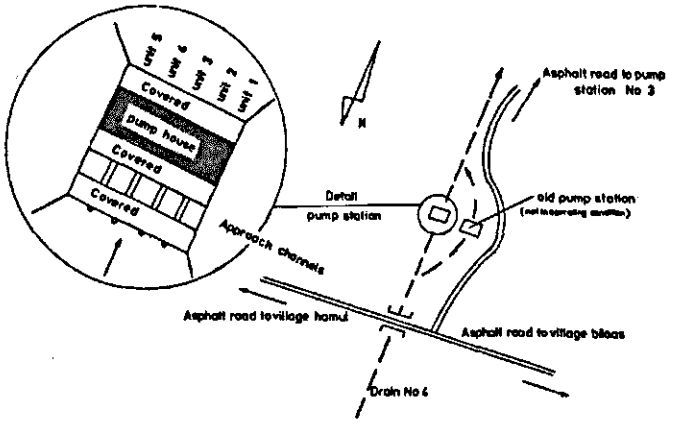
Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
8/12/79	2.13	7.55	4.38	4.55	12.0	0.2	-	4.8	7.87	8.46
7/01/80	2.24	8.2	4.8	3.6	13.9	0.2	-	3.8	5.0	13.5
28/01/80	4.33	7.6	9.0	4.1	30.0	0.1	-	4.9	8.7	29.6
11/02/80	5.78	7.4	11.0	10.4	36.2	0.2	-	5.3	11.7	40.8
26/02/80	2.21	7.3	5.0	5.5	11.4	0.2	-	3.6	7.0	11.5
10/03/80	2.04	7.3	4.7	7.3	8.2	0.2	-	3.6	5.8	11.0
24/08/80	2.64	-	6.3	5.3	14.6	0.2	-	8.0	2.7	15.7
14/04/80	2.47	7.2	5.0	5.9	13.0	0.2	-	0.8	7.1	16.5
21/04/80	2.13	7.5	4.0	4.1	13.0	0.1	-	4.4	6.3	10.5
5/05/80	2.29	7.4	4.2	5.3	13.2	0.22	-	2.3	12.7	8.0
27/05/80	2.16	7.6	5.0	3.55	13.0	0.05	-	4.4	5.2	12.0
4/06/80	2.46	7.55	6.2	6.1	12.0	0.3	-	2.2	7.5	15.0
16/06/80	2.33	7.1	5.0	4.5	13.6	0.2	-	5.2	1.7	16.4
1/07/80	2.73	7.1	6.0	4.5	15.6	0.2	-	5.2	5.6	16.5
16/07/80	2.73	7.3	3.6	4.9	19.0	0.18	-	4.75	7.75	15.18
1/08/80	2.82	7.7	6.3	5.2	16.5	0.2	-	5.4	6.9	15.9
18/08/80	2.73	7.4	5.2	5.6	15.3	1.1	-	5.4	6.2	15.6
22/09/80	2.73	7.5	5.7	5.8	15.7	0.1	-	5.2	6.0	16.1
4/10/80	2.46	7.3	3.2	2.8	17.4	1.2	-	6.2	3.6	14.8
27/10/80	2.18	8.0	5.0	5.0	11.9	0.1	-	6.6	2.7	12.7
11/11/80	2.46	7.8	5.1	6.0	13.7	0.2	-	7.6	2.1	15.3
24/11/80	3.28	7.4	8.0	4.8	18.9	1.1	-	4.5	14.0	14.3
7/12/80	3.19	7.4	5.78	6.22	18.7	0.5	-	4.8	12.5	14.4
25/12/80	2.55	8.1	3.9	3.7	17.8	0.1	-	5.4	15.9	4.2
7/01/81	1.15	7.1	2.0	3.14	6.14	0.22	-	4.51	0.71	6.38

1. 8. 5. EH 13, calibration measurements

Date	Hm	Q
10/03/79	-	48. 26
10/04/79	-	55. 57
19/05/79	-	53. 34
19/06/79	-	45. 09
14/07/79	-	48. 89
6/08/80	0. 54	53. 94
23/02/81	0. 57	40. 75
15/11/81	0. 54	46. 17
1/02/82	0. 67	7. 56

1. 9. MG 09, pump station no. 4

The measurement point is a drainage pump station (see fig. A 1-9)



No of pump units in operation: .....

EC : .....

Fig. A 1-9. Situation sketch MG 09 (taken from measurement forms)

1. 9. 2. MG 09, discharge measurements 1976 - 1980 (10^6 m^3. $month^{-1}$)

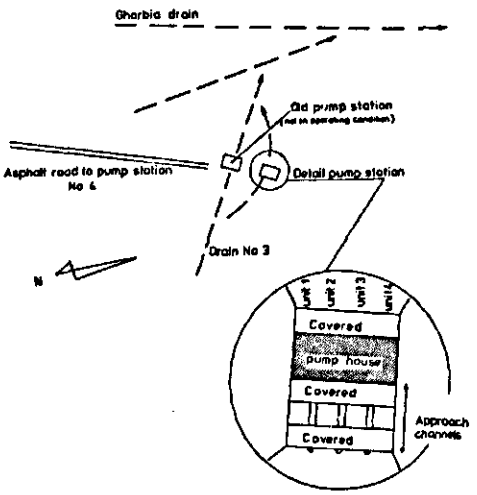
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	15. 997	22. 432	24. 124	21. 837	23. 969	36. 386	43. 472	42. 176	32. 912	29. 732	29. 144	21. 796
1977	19. 303	17. 491	27. 573	26. 983	23. 096	36. 421	44. 575	42. 891	33. 894	29. 862	25. 951	22. 768
1978	22. 608	12. 549	30. 449	32. 128	22. 222	36. 534	45. 677	43. 606	34. 875	29. 991	22. 758	23. 740
1979	19. 812	15. 798	26. 080	25. 521	24. 739	38. 983	49. 475	50. 929	40. 949	31. 767	22. 098	23. 743
1980	22. 053	15. 682	26. 703	27. 527	24. 855	32. 736	41. 587	47. 794	37. 477	35. 621	23. 127	27. 858

1. 9. 4. MG 09, waterquality measurement 1980 and 1981 (partly)

Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
16/04/80	1. 42	7. 45	3. 5	2. 68	8. 0	0. 22	-	3. 8	1. 6	9. 0
6/05/80	2. 13	7. 8	4. 2	4. 3	12. 28	0. 22	-	3. 6	4. 2	13. 2
20/05/80	1. 38	7. 4	3. 54	3. 74	5. 3	1. 5	-	3. 6	2. 32	8. 16
9/06/80	1. 07	7. 6	2. 1	2. 4	6. 08	0. 22	-	4. 0	0. 69	6. 11
22/06/80	1. 92	7. 7	2. 75	4. 74	11. 56	0. 45	-	4. 82	6. 36	8. 34
8/07/80	1. 48	7. 55	2. 63	4. 61	7. 54	0. 22	-	4. 68	1. 58	8. 74
25/07/80	1. 43	8. 0	3. 15	2. 85	8. 36	0. 14	-	4. 99	1. 71	7. 8
7/08/80	1. 27	7. 3	4. 73	1. 77	6. 5	0. 12	-	4. 99	0. 85	7. 22
30/08/80	1. 32	7. 65	3. 15	1. 85	8. 6	0. 12	-	4. 7	1. 37	7. 65
14/09/80	1. 40	7. 6	3. 15	2. 35	7. 88	0. 62	-	4. 8	0. 53	8. 67
27/09/80	1. 51	7. 6	3. 21	6. 79	4. 88	0. 12	-	5. 4	1. 5	8. 1
15/10/80	1. 04	7. 4	3. 68	2. 83	3. 89	0. 11	-	4. 88	1. 04	4. 58
6/11/80	1. 40	7. 55	5. 52	1. 49	6. 69	0. 3	-	5. 04	0. 36	8. 6
20/11/80	1. 40	7. 4	3. 89	6. 94	3. 7	0. 16	-	4. 0	2. 4	8. 3
30/12/80	2. 28	7. 5	4. 4	1. 8	16. 5	0. 2	-	4. 7	8. 3	9. 9
23/01/81	2. 09	8. 0	4. 8	6. 3	10. 0	0. 4	-	4. 0	8. 2	9. 3
9/02/81	6. 44	7. 2	14. 3	14. 2	35. 4	1. 2	-	9. 8	4. 0	51. 3
22/02/81	2. 32	7. 0	6. 5	6. 1	10. 3	0. 5	-	4. 0	3. 6	15. 7
6/03/81	1. 81	7. 6	6. 5	0. 6	10. 0	0. 9	-	4. 0	3. 8	10. 2
21/03/81	2. 26	7. 6	3. 8	5. 3	13. 3	0. 2	-	3. 5	2. 2	16. 9
4/04/81	1. 36	8. 2	3. 1	3. 0	7. 3	0. 2	-	3. 3	6. 8	3. 5

1.10. MG 10, pump station no. 3

The measurement point is a drainage pump station (see fig. A 1-10)



No of pump units in operation: .....

EC: .....

Fig. A 1-10. Situation sketch MG 10
(taken from measurements forms)

1.10.2. MG 10, discharge measurements 1976 - 1980 ($10^6 m^3$ month^{-1})

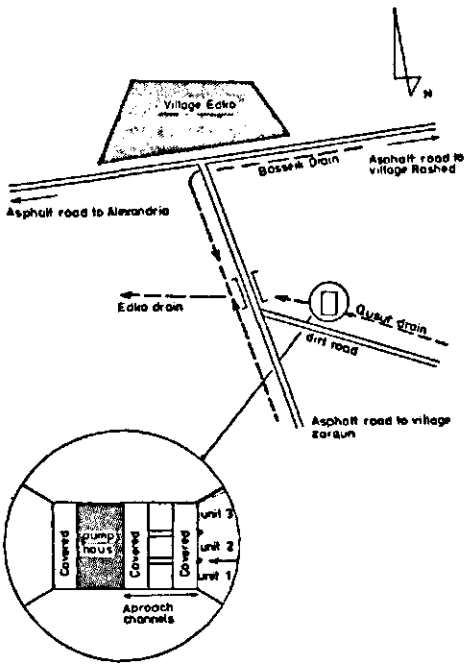
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	14.971	21.000	21.286	20.927	18.345	32.022	40.220	39.761	34.668	26.974	23.275	19.192
1977	17.321	15.587	24.873	21.527	19.143	31.396	36.133	36.206	32.717	27.252	22.106	19.710
1978	19.671	10.173	28.159	22.127	19.941	30.766	32.146	32.651	30.766	27.530	20.676	20.228
1979	18.480	17.377	21.195	23.804	21.383	33.102	44.605	45.614	17.400	28.061	20.578	23.078
1980	20.539	15.165	23.190	20.471	21.275	34.060	39.533	41.560	42.988	33.202	19.419	25.360

1.10.4. MG 10, waterquality measurements 1980 and 1981 (partly)

Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
16/04/80	2.29	7.55	4.5	5.0	13.0	0.2	-	4.0	5.21	13.5
6/05/80	2.04	7.7	4.4	2.1	13.75	0.25	-	4.0	6.05	10.45
20/05/80	2.04	7.2	2.73	4.55	10.5	0.35	-	3.6	3.01	11.52
9/06/80	2.30	7.8	2.63	4.87	15.2	0.3	-	4.16	3.8	15.04
22/06/80	2.83	7.6	3.0	6.16	18.96	0.18	-	4.64	8.58	15.08
8/07/80	2.73	7.7	4.73	4.77	17.68	0.32	-	4.68	5.34	17.48
25/07/80	2.21	7.6	4.2	3.8	14.04	0.16	-	5.1	4.1	13.0
7/08/80	1.91	7.5	4.2	4.3	13.5	0.16	-	5.2	3.96	13.0
25/08/80	2.00	7.4	3.15	4.35	12.4	0.23	-	5.08	2.3	12.75
14/09/80	2.73	7.5	3.15	5.6	17.95	0.3	-	5.09	5.59	16.32
27/09/80	2.82	7.6	3.94	6.57	17.53	0.16	-	5.6	5.95	16.65
15/10/80	1.69	7.6	5.25	5.75	5.78	0.12	-	6.44	4.6	5.9
6/11/80	1.00	7.5	3.15	1.85	4.65	0.35	-	3.16	0.8	6.04
20/11/80	2.49	7.25	4.77	5.34	14.57	0.22	-	6.37	1.51	17.02
30/12/80	3.64	7.4	4.85	5.6	32.0	0.55	-	4.7	16.21	22.09
23/01/81	2.37	7.9	4.8	3.4	15.0	0.4	-	4.5	7.7	11.3
9/02/81	8.31	7.4	11.7	18.8	51.1	1.4	-	5.0	14.2	63.8
24/02/81	2.26	7.2	0.2	2.3	15.7	0.3	-	4.3	3.4	15.8
6/03/81	2.03	7.8	5.9	1.5	12.5	0.2	-	3.5	1.6	14.9
21/03/81	2.83	7.5	5.4	6.0	20.0	0.2	-	3.8	3.6	23.5
4/04/81	1.92	7.5	3.4	4.4	12.0	0.2	-	3.6	2.9	13.5

1.11. WE 10, Edko pump station

The measurement point is a drainage pump station (see fig. A 1-11)



No of pump units in operation: .....

EC: .....

Fig. A 1-11. Situation sketch WE 10
(taken from measurement forms)

1.11.2. WE 10, discharge measurements 1980 ($10^6 m^3$ decade^{-1})

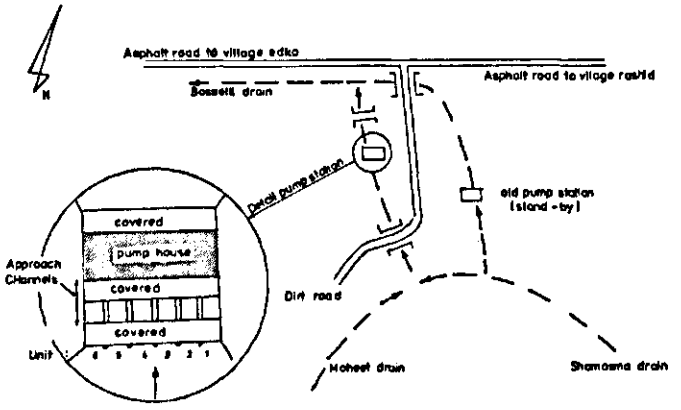
Decade	Jan.	Febr.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
I	1.65	1.88	1.23	3.82	4.36	5.49	7.73	8.14	8.88	6.13	4.48	4.24
II	2.12	1.69	2.25	3.85	4.73	5.24	7.64	7.85	8.89	5.17	5.39	2.25
III	1.56	1.45	5.36	3.99	4.74	5.88	8.49	8.50	8.67	4.96	4.67	-

1.11.4. WE 10, water quality measurements 1980 and 1981 (partly)

Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
12/03/80	7.82	7.7	6.8	13.2	60.0	1.0	-	5.0	14.5	61.4
24/03/80	3.91	7.2	4.5	5.5	29.4	0.8	-	9.6	0.4	30.2
9/04/80	4.93	7.4	4.5	10.2	40.0	0.8	-	5.0	15.0	35.5
22/04/80	4.67	7.7	3.2	3.4	39.6	0.6	-	2.8	14.9	29.0
13/05/80	3.83	7.7	4.7	8.8	24.4	0.4	-	5.6	0.8	31.9
21/05/80	3.74	6.7	7.1	6.4	24.0	0.2	-	5.6	1.8	30.2
4/06/80	3.15	7.6	3.8	8.8	17.2	1.8	-	4.8	1.2	25.4
14/06/80	4.30	7.9	3.0	11.7	27.5	1.1	-	3.7	6.2	33.4
2/07/80	4.00	7.6	5.1	9.3	27.0	0.6	-	8.0	6.4	27.6
16/07/80	3.55	7.8	5.1	4.4	25.5	0.6	-	6.8	6.2	22.5
2/08/80	3.45	7.7	4.7	5.3	24.3	0.2	-	6.5	4.1	23.9
18/08/80	3.28	7.6	3.2	6.9	22.2	0.6	-	6.1	6.3	20.4
2/09/80	2.91	7.4	4.6	3.9	21.4	0.4	-	5.9	6.5	17.9
18/09/80	3.28	7.6	3.4	6.1	22.9	0.5	-	5.6	5.8	21.4
27/09/80	3.28	7.7	4.7	8.3	20.0	0.4	-	6.8	6.4	20.3
13/10/80	3.55	7.5	4.7	8.3	22.5	0.2	-	7.8	1.5	26.3
2/11/80	4.00	7.5	4.5	9.5	25.0	1.1	-	7.4	6.2	26.4
16/11/80	4.55	8.0	6.8	8.7	30.0	0.2	-	5.3	19.2	21.2
3/12/80	5.00	7.4	4.2	7.3	37.5	1.1	-	4.8	15.8	29.4
17/12/80	6.55	7.1	5.22	10.12	54.0	0.82	-	4.7	40.46	24.7
30/12/80	6.37	7.9	3.7	12.8	54.6	0.7	-	4.7	45.3	21.8
20/01/81	7.55	7.4	3.8	11.3	70.0	0.9	-	10.0	27.4	48.6
3/02/81	13.29	8.0	16.35	27.12	108.0	0.9	-	8.2	66.17	78.0
8/02/81	4.75	7.05	6.5	20.8	28.0	0.7	-	7.3	3.2	45.5
25/02/81	5.20	6.9	6.5	11.4	44.0	0.6	-	5.0	6.6	50.8

1.12. WE 11, Bosseili pump station

The measurement point is a drainage pump station (see fig. A 1-12)



No pump units in operation: .....

EC: .....

Fig. A 1-12. Situation sketch WE 11 (taken from measurement forms)

1.12.2. WE 11, discharge measurements 1980 ($10^6 m^3$ decade^{-1})

Decade	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
I	1.74	2.19	4.05	6.92	8.30	7.83	9.25	6.29	10.02	9.39	3.14	4.36
II	2.67	3.60	7.11	8.45	8.87	7.66	9.47	9.89	9.59	4.85	3.93	3.85
III	1.83	3.72	7.37	8.45	5.78	9.52	7.10	10.82	7.93	4.99	4.45	3.95

1.12.4. WE 11, waterquality measurements 1980 and 1981 (partly)

Date	EC	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
12/03/80	2.21	7.7	3.0	3.7	15.3	0.3	-	3.0	3.4	15.8
24/03/80	2.21	7.4	3.5	3.6	14.6	0.5	-	7.2	1.5	13.5
9/04/80	2.55	7.4	3.8	5.3	16.0	0.5	-	4.0	4.5	17.0
22/04/80	1.79	7.9	3.4	3.1	11.4	0.2	-	2.8	5.3	10.0
13/05/80	1.96	7.9	3.7	4.3	10.2	0.4	-	4.4	3.0	12.1
21/05/80	1.87	6.7	7.4	2.0	9.2	0.2	-	5.2	3.5	10.1
4/06/80	1.21	7.4	3.5	3.7	4.6	0.2	-	4.4	1.4	6.2
14/06/80	2.04	7.9	5.0	5.7	9.2	0.5	-	3.6	5.4	11.4
2/07/80	1.87	7.6	4.1	3.5	10.7	0.4	-	6.8	0.4	11.5
16/07/80	1.41	7.6	2.0	3.8	8.0	0.3	-	5.8	1.4	6.9
2/08/80	1.65	7.2	3.2	3.4	9.7	0.2	-	5.4	1.7	9.4
18/08/80	1.57	7.3	3.7	2.8	8.8	0.4	-	5.3	1.7	8.7
2/09/80	1.53	7.4	3.7	3.8	7.5	0.4	-	5.9	0.8	8.7
18/09/80	1.82	7.8	5.7	1.1	11.0	0.4	-	6.0	1.4	10.7
27/09/80	2.00	7.3	4.2	4.3	11.2	0.3	-	5.2	3.6	11.3
13/10/80	1.82	8.4	4.2	3.8	10.0	0.2	-	4.8	1.2	12.2
2/11/80	1.67	7.2	3.7	3.3	9.3	0.4	-	6.2	1.6	8.9
16/11/80	2.18	7.8	4.0	5.5	12.0	0.5	-	4.6	8.6	8.7
3/12/80	2.00	7.5	3.2	3.9	12.7	0.4	-	4.4	8.3	7.4
17/12/80	3.64	7.1	4.8	6.2	26.0	0.5	-	6.2	8.94	26.0
30/12/80	3.37	7.6	3.2	6.9	25.6	0.5	-	4.3	10.6	21.2
20/01/81	28.21	7.05	11.0	36.0	280.0	2.7	-	8.5	116.3	204.9
3/02/81	22.75	7.55	20.4	30.6	188.0	0.88	-	10.8	73.08	156.0
8/02/81	9.83	7.5	10.4	16.4	95.0	3.0	-	6.5	14.3	104.0
25/02/81	2.82	7.2	4.6	6.0	20.0	0.5	-	4.4	3.3	23.3

ANNEX 2: PROCESSED DATA

2.1. FB 03, Batts drain at Furgus

2.2. FB 04, Roda drain

2.3. FB 05, Batts drain at Tamya

2.4. EB 07, Bahr Bagar drain at 'Kubri Saud'

2.5. EB 08, Bahr Bagar drain at 'Kubri Bahr Bagar'

2.6. EH 02, Hanut pump station

2.7. EH 11, Bahr Hadus at 'Kubri Bahr Hadus'

2.8. EH 13, Bahr Hadus at 'Outfall'

2.9. MG 09, pump station No. 4

2.10. MG 10, pump station No. 3

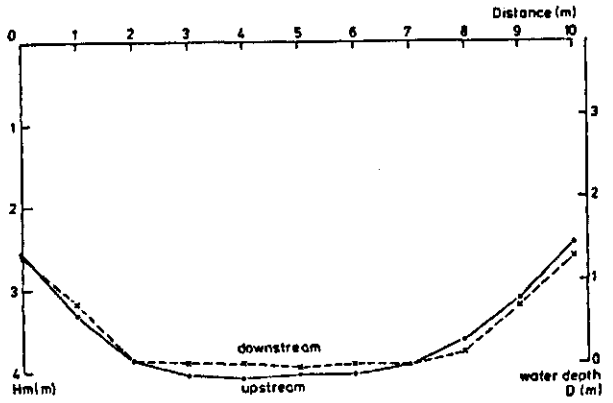
2.11. WE 10, Edko pump station

2.12. WE 11, Bosseili pump station

* cross section at measurement location
* calculation sheets
* calibration measurements

2. 1. FB 03, Batts drain at Furgus

2. 1. 1. FB 03, cross section at measurement location



Date of observation : 17/09/80
Depth at reference point: 3. 88 m
Bridge width : 5. 05 m
Cross section width : 10. 00 m

Distance from zero point (m)	Effective section width (m) w	Area cross section (m^2) for Hm = 0; D = 3. 88 A_s
1	2. 00	6. 39
3	2. 00	7. 79
5	2. 00	7. 87
7	2. 00	7. 64
9	2. 00	6. 17

Fig. A2-1. FB 03, cross section at measurement location

2. 1. 2. FB 03, calculation sheet

Observation year : 1980
Catchment area : Batts drain
Measurement point : FB 03
Remarks :

Waterdepth : D = 3. 88 - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

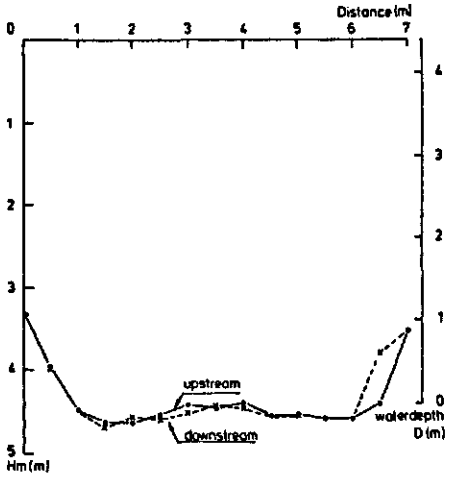
Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79		1. 40	11. 06	0. 273	-	3. 02	1. 18	800	8. 0	3. 3	7. 8	0. 0	3. 1	2. 7	5. 6	0. 3	0. 0	5. 5	0. 6	5. 6
01/01/80																				
09/01/80		1. 58	12. 86	0. 336	-	4. 32	1. 45	940	8. 3	2. 7	6. 4	0. 0	3. 6	5. 3	5. 6	0. 1	0. 0	4. 2	3. 4	7. 0
23/01/80		0. 51	3. 08	0. 198	-	0. 61	3. 85-		7. 4				6. 6	10. 1	35. 0	0. 7	0. 0	5. 3	17. 0	30. 1
01/02/80																				
06/02/80		0. 46	2. 78	0. 233	-	0. 65	4. 17	3140	7. 4	8. 8	25. 3	0. 0	8. 5	11. 7	28. 0	0. 7	0. 0	8. 8	16. 1	24. 0
24/02/80		1. 69	13. 96	0. 346	-	4. 83	0. 94	640	7. 6	3. 7	7. 5	0. 0	2. 6	1.	5. 2	0. 4	0. 0	3. 5	0. 8	5. 3
01/03/80																				
14/03/80		1. 16	8. 66	0. 367	-	3. 18	1. 43	950	7. 8	3. 3	8. 1	0. 0	4. 5	3. 1	6. 5	0. 1	0. 0	5. 2	2. 8	6. 2
01/04/80																				
04/04/80		1. 08	7. 86	0. 470	1. 353	3. 69	1. 28	870	7. 5	4. 5	9. 6	0. 0	4. 0	1. 2	7. 3	0. 3	0. 0	3. 5	3. 9	5. 4
18/04/80		1. 08	7. 86	0. 409	0. 622	3. 22	1. 45	990	7. 4	4. 9	10. 9	0. 0	3. 0	3. 2	8. 6	0. 2	0. 0	4. 0	4. 0	7. 0
30/04/80		1. 11	8. 16	0. 452	0. 698	3. 69	1. 22	810	7. 6	4. 4	9. 6	0. 0	2. 6	2. 4	7. 0	0. 2	0. 0	4. 0	2. 2	6. 0
01/05/80																				
18/05/80		1. 03	7. 36	0. 451	0. 762	3. 32	1. 51	1000	8. 0	5. 3	11. 7	0. 0	3. 0	2. 7	9. 0	0. 3	0. 0	4. 0	4. 4	6. 6
01/06/80																				
02/06/80		0. 85	5. 56	0. 380	-	2. 11	1. 24	840	7. 8	4. 3	9. 8	0. 0	3. 8	1. 4	7. 0	0. 2	0. 0	4. 8	1. 0	6. 6
28/06/80		0. 94	6. 46	0. 428	0. 597	2. 76	1. 33	900	7. 3	3. 8	8. 7	0. 0	4. 5	1. 8	6. 7	0. 3	0. 0	4. 4	3. 3	5. 6
01/07/80																				
11/07/80		0. 86	5. 66	0. 383	0. 579	2. 17	1. 78	1260	7. 7	7. 9	17. 1	0. 0	3. 6	1. 8	13. 0	0. 2	0. 0	4. 1	7. 6	6. 9
25/07/80		1. 02	7. 26	0. 345	0. 540	2. 51	0. 98-		7. 5				3. 2	2. 4	7. 8	0. 2	0. 0	2. 1	5. 8	5. 7
01/08/80																				
01/09/80																				
17/09/80		1. 38	10. 86	0. 313	0. 568	3. 40	1. 31	910	7. 6	4. 9	11. 3	0. 8	3. 2	1. 8	7. 7	0. 4	0. 0	5. 8	1. 2	6. 1
01/10/80																				
11/10/80		1. 22	9. 26	0. 291	0. 478	2. 70	1. 66	1130	7. 9	5. 0	12. 5	0. 0	3. 7	3. 3	9. 3	0. 2	0. 0	7. 0	2. 1	7. 4
01/11/80																				
04/11/80		0. 91	6. 16	0. 338	0. 528	2. 09	1. 68	1180	7. 9	5. 3	13. 4	0. 0	3. 7	3. 3	10. 0	0. 2	0. 0	7. 0	2. 8	7. 4
09/11/80		1. 12	8. 26	0. 308	0. 475	2. 54	1. 58	1070	7. 8	4. 8	11. 7	0. 0	3. 9	2. 8	8. 7	0. 2	0. 0	6. 4	3. 0	6. 2
01/12/80																				
17/12/80		1. 21	9. 16	0. 353	0. 598	3. 23	2. 00	1380	7. 3	5. 9	13. 0	0. 0	4. 2	3. 8	11. 7	0. 4	0. 0	3. 4	13. 5	3. 2
01/01/81																				
17/01/81		1. 16	8. 66	0. 375	0. 382	3. 25	2. 37	1490	7. 3	5. 4	13. 3	0. 0	4. 6	6. 3	12. 5	0. 2	0. 0	4. 8	5. 0	13. 8

2. 1. 3. FB 03, calibration measurements

Date	D	Discharge
17/01/82	0. 49	0. 51
04/02/82	0. 57	1. 04

2. 2. FB 04, Roda drain

2. 2. 1. FB 04, cross section at measurement location



Date of observation : 17/09/80
Depth at reference point: 4. 04 m
Bridge width : 8. 10 m
Cross-section width : 7. 00 m

Distance from zero point(m)	Effective section width(m) w	Area cross section (m^2) for Hm = 0; D = 3. 88 A_s
0. 5	1. 00	3. 89
1. 5	1. 00	4. 54
2. 5	1. 00	4. 50
3. 5	1. 00	4. 39
4. 5	1. 00	4. 46
5. 5	1. 00	4. 51
6. 5	1. 00	4. 01

Fig. A 2-2. FB 04, cross section at measurement location

2. 2. 2. FB 04, calculation sheet

Observation year : 1980
Catchment area : Batts drain
Measurement point : FB 04
Remarks :

Waterdepth : D = 4. 04 - Hm
Pendulum constant : c_P = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
17/12/80*		0. 93	6. 01	0. 668		4. 01	2. 18	1530	7. 2	8. 3	18. 2	0. 0	3. 2	3. 4	15. 0	0. 4	0. 0	4. 0	14. 3	3. 7
01/01/80																				
09/01/80		0. 55	3. 35	0. 865		2. 90	2. 47	1590	8. 4	5. 4	13. 5	0. 0	5. 4	6. 1	13. 0	0. 2	0. 0	4. 7	8. 7	11. 3
23/01/80		0. 01	0. 45	0. 264		0. 12	8. 42	5980	7. 4	16. 8	49. 3	0. 0	6. 8	23. 1	65. 0	0. 7	0. 0	9. 3	33. 2	53. 1
01/02/80																				
06/02/80		-0. 02	0. 33	0. 454		0. 15	8. 25	6160	7. 6	18. 2	49. 6	0. 0	14. 8	13. 4	68. 5	0. 6	0. 0	5. 8	40. 1	51. 4
24/02/80		0. 67	4. 19	1. 143		4. 79	1. 87	1250	7. 6	4. 9	11. 7	0. 0	5. 2	3. 3	10. 2	0. 4	0. 0	4. 4	5. 6	9. 1
01/03/80																				
14/03/80		0. 44	2. 65	1. 159		3. 07	2. 13	1400	7. 9	3. 7	10. 1	0. 0	5. 0	6. 9	9. 1	0. 2	0. 0	7. 2	4. 9	9. 1
01/04/80																				
04/04/80		0. 44	2. 65	1. 014		2. 69	1. 87	1240	7. 5	4. 9	11. 6	0. 0	5. 0	3. 2	10. 0	0. 4	0. 0	4. 2	7. 2	7. 2
18/04/80		0. 50	3. 01	0. 901		2. 71	1. 42	930	7. 4	4. 9	10. 8	0. 0	3. 0	2. 7	8. 3	0. 2	0. 0	4. 0	2. 7	7. 5
30/04/80		0. 51	3. 07	0. 901		2. 77	1. 44	970	7. 6	6. 5	13. 7	0. 0	2. 6	1. 9	9. 8	0. 2	0. 0	4. 0	3. 3	7. 2
01/05/80																				
18/05/80		0. 45	2. 71	0. 911		2. 47	1. 48	970	7. 9	5. 2	12. 0	0. 0	3. 0	2. 7	8. 8	0. 2	0. 0	5. 2	1. 0	8. 5
01/06/80																				
02/06/80		0. 15	1. 15	0. 807		0. 93	2. 38	1570	7. 9	7. 0	17. 2	0. 0	5. 4	3. 4	14. 6	0. 3	0. 0	5. 6	7. 5	10. 6
28/06/80		0. 20	1. 40	0. 675		0. 95	2. 72	1770	7. 4	8. 2	19. 8	0. 0	4. 7	4. 5	17. 6	0. 4	0. 0	5. 0	9. 0	13. 2
01/07/80																				
11/07/80		0. 22	1. 50	1. 112		1. 67	2. 81	1820	7. 4	10. 5	23. 9	0. 0	4. 2	3. 0	20. 0	0. 4	0. 0	4. 5	10. 2	12. 9
25/07/80		0. 35	2. 15	0. 777		1. 67	2. 73+		7. 4				4. 7	4. 3	16. 2	0. 2	0. 0	4. 4	8. 5	12. 5
01/08/80																				
01/09/80																				
17/09/80		0. 95	6. 15	0. 587		3. 61	2. 28	1520	7. 7	8. 2	19. 0	0. 0	4. 2	2. 8	15. 4	0. 4	0. 0	4. 8	8. 3	9. 7
01/10/80																				
11/10/80		0. 90	5. 80	0. 686		3. 98	2. 18	1490	8. 0	6. 2	15. 8	0. 0	5. 8	3. 0	13. 0	0. 2	0. 0	6. 7	6. 2	9. 1
01/11/80																				
04/11/80		0. 76	4. 82	0. 691		3. 33	2. 22	1520	8. 0	6. 4	16. 4	0. 0	5. 8	3. 0	13. 5	0. 2	0. 0	6. 7	6. 7	9. 1
09/11/80		0. 75	4. 75	0. 742		3. 52	2. 27	1530	7. 9	6. 3	15. 9	0. 0	5. 5	3. 5	13. 3	0. 4	0. 0	6. 4	7. 2	9. 1
01/12/80																				
17/12/80		0. 93	6. 01	0. 668		4. 01	2. 18	1530	7. 2	8. 3	18. 2	0. 0	3. 2	3. 4	15. 0	0. 4	0. 0	4. 0	14. 3	3. 7
01/01/81																				
17/01/81		0. 88	5. 66	0. 661		3. 74	2. 73-		7. 2				5. 9	3. 6	22. 0	0. 4	0. 0	4. 8	8. 5	18. 6

2. 2. 3. FB 04, calibration measurements

Date	Waterdepth	Discharge
17/01/82	0. 04	0. 33

2. 3. FB 05, Batts drain at Tamya

2. 3. 1. FB 05, cross section at measurement location

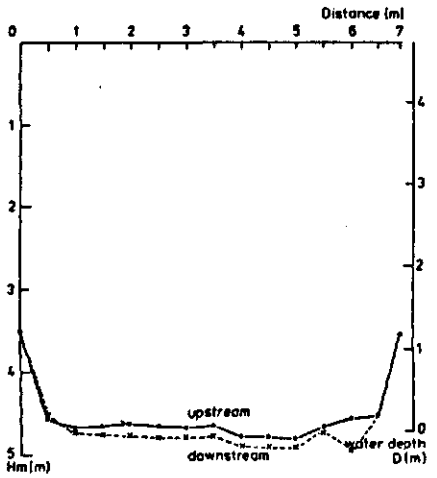


Fig. A 2-3. FB 05, cross section at measurement location

Date of observation : 17/09/80
Depth at reference point: 4. 72
Bridge width : 8. 05 m
Cross section width : 6. 90 m

Distance from zero point(m)	Effective section width(m) w	Area cross section (m^2) for Hm = 0; D = 4. 72 A_s
0. 5	1. 00	4. 32
1. 5	1. 00	4. 68
2. 5	1. 00	4. 68
3. 5	1. 00	4. 69
4. 5	1. 00	4. 77
5. 5	1. 00	4. 65
6. 5	0. 90	3. 83

2. 3. 2. FB 05, calculation sheet

Observation year : 1980
Catchment area : Batts drain
Measurement point : FB 05
Remarks :

Waterdepth : D = 4. 72 - Hm
Pendulum constant : c_p = _____
Float constant : c_D = _____ + _____ D
Calibration : Q = _____ (D _____) _____

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79		1. 24	7. 61	1. 207		9. 18	1. 31	890	8. 0	3. 1	7. 5	0. 0	4. 0	3. 2	5. 8	0. 2	0. 0	5. 5	1. 6	6. 1
01/01/80																				
09/01/80		1. 17	7. 13	1. 262		8. 99	1. 87	1240	8. 6	5. 4	12. 9	0. 0	4. 2	3. 6	10. 6	0. 3	0. 0	5. 1	5. 1	8. 5
23/01/80		0. 33	1. 52	0. 618		0. 94	5. 70	3460	7. 8	11. 0	27. 9	0. 0	6. 6	13. 7	35. 0	0. 6	0. 0	4. 2	19. 7	32. 0
01/02/80																				
06/02/80		0. 22	0. 97	0. 863		0. 84	11. 82	8250	7. 7	29. 7	82. 5	0. 0	12. 7	10. 0	100. 0	0. 3	0. 0	8. 6	78. 4	36. 0
24/02/80		1. 31	8. 09	1. 332		10. 78	0. 95	660	7. 1	3. 8	7. 0	0. 0	3. 7	0. 4	5. 5	0. 3	0. 0	2. 3	2. 3	5. 3
01/03/80																				
14/03/80		0. 93	5. 47	1. 215		6. 65	1. 96	1300	7. 4	4. 4	11. 7	0. 0	4. 0	5. 5	9. 6	0. 3	0. 0	8. 0	2. 3	9. 1
01/04/80																				
04/04/80		1. 00	5. 95	1. 720		10. 24	1. 02	730	7. 6	3. 9	8. 4	0. 1	3. 5	0. 8	5. 7	0. 3	0. 0	4. 4	2. 1	3. 8
18/04/80		1. 02	6. 09	1. 308		7. 97	1. 45	960	7. 4	5. 1	11. 2	0. 0	3. 5	2. 2	8. 6	0. 2	0. 0	4. 0	3. 0	7. 5
30/04/80		1. 06	6. 37	1. 359		8. 65	1. 29	860	7. 3	4. 4	9. 7	0. 0	2. 9	2. 6	7. 3	0. 2	0. 0	4. 0	2. 4	6. 6
01/05/80																				
18/05/80		0. 83	4. 78	1. 344		6. 42	1. 34	860	7. 9	3. 5	8. 0	0. 0	3. 5	3. 2	6. 4	0. 2	0. 0	4. 0	1. 6	7. 7
01/06/80																				
02/06/80		0. 59	3. 12	1. 286		4. 02	1. 59	1040	8. 0	3. 2	7. 8	0. 0	4. 9	3. 9	6. 8	0. 2	0. 0	4. 4	4. 4	7. 0
28/06/80		0. 70	3. 88	1. 080		4. 19	2. 04	1360	7. 4	6. 2	14. 9	0. 0	4. 2	3. 6	12. 3	0. 4	0. 0	5. 0	6. 1	9. 4
01/07/80																				
11/07/80		0. 70	3. 88	1. 130		4. 39	2. 29	1530	7. 6	11. 3	23. 2	0. 0	3. 1	1. 8	17. 7	0. 3	0. 0	3. 8	9. 4	9. 7
25/07/80		0. 92	5. 40	1. 055		5. 70	2. 09+		7. 8				2. 6	2. 4	11. 0	0. 1	0. 0	4. 8	2. 5	8. 8
01/08/80																				
01/09/80																				
17/09/80		1. 32	8. 16	1. 098		8. 96	1. 91	1280	7. 8	7. 4	16. 8	0. 0	3. 7	2. 3	12. 8	0. 2	0. 0	4. 8	6. 0	8. 2
01/10/80																				
11/10/80		1. 24	7. 61	1. 122		8. 53	1. 91	1350	7. 7	5. 5	14. 0	0. 0	3. 7	4. 8	11. 3	0. 2	0. 0	6. 7	5. 6	7. 7
01/11/80																				
04/11/80		1. 09	6. 57	0. 953		6. 26	1. 94	1400	7. 7	5. 8	14. 8	0. 0	3. 7	4. 8	12. 0	0. 2	0. 0	6. 7	6. 3	7. 7
09/11/80		1. 11	6. 71	0. 993		6. 66	2. 00	1380	8. 4	6. 3	15. 8	0. 0	4. 5	3. 0	12. 2	0. 4	0. 0	7. 0	4. 9	8. 2
01/12/80																				
17/12/80		1. 30	8. 02	1. 029		8. 25	2. 00	1400	7. 4	6. 8	15. 5	0. 0	3. 7	3. 3	12. 7	0. 4	0. 0	4. 4	12. 0	3. 7
01/01/81																				
17/01/81		1. 32	8. 16	1. 029		8. 39	2. 46	1560	7. 2	7. 9	18. 8	0. 0	3. 6	4. 6	16. 0	0. 4	0. 0	5. 0	4. 2	15. 4

2. 3. 3. FB 05, calibration measurements

Date	Waterdepth	Discharge
14/07/81	0. 75	4. 82
14/01/82	0. 36	2. 55
04/02/82	0. 31	1. 67

Regression line : $Q = 6,76\ D^{1,09}$, $R^2 = 0,94$

2. 4. EB 07, Bahr Bagar drain at 'Kubri Saud"

2. 4. 1. EB 07, cross section at measurement location

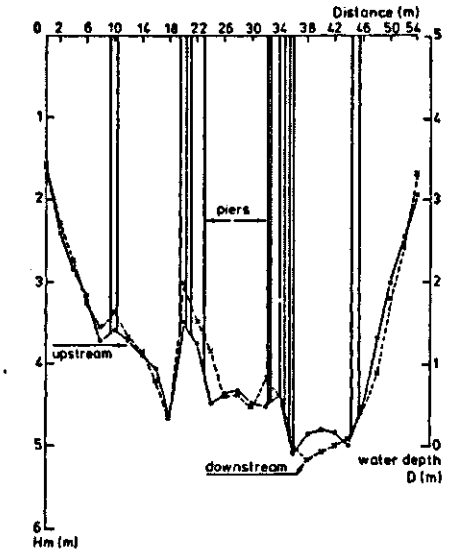


Fig. A 2-4. EB 07, cross section at measurement location

Date of observation : 08/12/80
Depth at reference point : 5. 02 m
Bridge width : 4. 05 m
Cross section width : 54. 00 m

Distance from zero point(m)	Effective section width(m) w	Area cross section (m^2) for Hm = 0; D = 5. 02 A_s
2	4. 00	8. 96
6	4. 00	12. 88
10	3. 40	12. 23
14	4. 00	15. 39
18	3. 70	15. 59
22	3. 10	11. 74
26	4. 00	17. 09
30	3. 90	17. 07
34	2. 30	10. 21
38	4. 00	19. 79
42	4. 00	19. 51
46	3. 40	14. 94
50	4. 00	12. 46
53	2. 00	4. 26

2. 4. 2. EB 07, calculation sheet

Observation year : 1980
Catchment area : Bahr baqar drain
Measurement point : EB 07
Remarks :

Waterdepth : D = 5, 02 - Hm
Pendulum constant : c_p = _____
Float constant : c_D = _____ + _____ D
Calibration : Q = _____ (D _____) _____

Date	P	D (Δ)H (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79		3. 27	104. 97	0. 424		44. 48	1. 02	730	7. 1	3. 2	7. 3	0. 3	4. 4	0. 6	5. 0	0. 2	0. 0	5. 3	0. 8	4. 1
01/01/80																				
06/01/80		3. 04	93. 52	0. 387		36. 20	1. 18	820	7. 2	3. 1	7. 3	0. 0	3. 6	2. 4	5. 4	0. 3	0. 0	5. 1	2. 8	3. 8
27/01/80		2. 92	87. 54	0. 453		39. 63	1. 46	1010	7. 6	3. 0	7. 6	0. 0	4. 6	3. 8	6. 1	0. 1	0. 0	7. 7	0. 8	6. 1
01/02/80																				
10/02/80		2. 74	79. 04	0. 382		30. 21	1. 45	970	7. 6	2. 9	7. 4	0. 0	4. 7	3. 3	5. 7	0. 2	0. 0	7. 4	1. 2	5. 3
25/02/80		3. 05	94. 01	0. 448	1. 143	42. 14	1. 79	1180	7. 2	7. 1	16. 1	0. 0	3. 7	2. 0	12. 0	0. 2	0. 0	4. 9	3. 4	9. 6
01/03/80																				
09/03/80		2. 96	89. 53	0. 460	0. 562	41. 20	1. 17	780	7. 7	0. 5	1. 4	0. 0	5. 2	5. 2	1. 2	0. 2	0. 0	5. 2	2. 3	4. 3
23/03/80		2. 91	87. 04	0. 313	0. 554	27. 23	1. 45	1080	-	3. 7	9. 9	3. 5	3. 7	3. 6	7. 0	0. 2	0. 0	10. 8	0. 1	3. 6
01/04/80																				
13/04/80		2. 84	83. 66	0. 447	0. 522	37. 37	1. 16	770	7. 5	2. 8	4. 7	0. 0	3. 5	3. 1	5. 1	0. 3	0. 0	1. 2	5. 8	5. 0
20/04/80		2. 81	82. 22	0. 532	0. 563	43. 78	1. 12	800	7. 3	3. 3	7. 9	0. 7	3. 0	2. 7	5. 5	0. 1	0. 0	6. 4	0. 9	4. 0
01/05/80																				
04/05/80		2. 81	82. 22	0. 397	0. 543	32. 65	1. 22	820	7. 2	3. 9	8. 3	0. 0	3. 2	2. 4	6. 6	0. 1	0. 0	3. 2	4. 1	5. 0
26/05/80		2. 88	85. 57	0. 313	0. 539	26. 80	1. 00	700	7. 4	1. 7	4. 1	0. 0	3. 2	3. 4	3. 0	0. 4	0. 0	5. 6	1. 0	3. 4
01/06/80																				
03/06/80		2. 90	86. 54	0. 388	0. 537	33. 61	1. 07	760	7. 0	2. 5	6. 2	1. 1	2. 6	3. 5	4. 3	0. 2	0. 0	7. 2	0. 0	3. 5
15/06/80		2. 86	84. 61	0. 465	0. 725	39. 38	1. 04	710	7. 4	2. 3	5. 5	0. 0	4. 4	1. 7	4. 0	0. 2	0. 0	5. 2	0. 4	4. 7
29/06/80		2. 88	85. 57	0. 464	0. 684	39. 74	1. 13	710	7. 4	2. 3	5. 5	0. 0	4. 4	1. 7	4. 0	0. 2	0. 0	5. 2	0. 4	4. 7
01/07/80																				
16/07/80		2. 95	89. 03	0. 402	0. 661	35. 84	1. 20	820	7. 3	5. 7	11. 7	0. 1	2. 2	1. 8	8. 0	0. 2	0. 0	4. 1	1. 8	6. 3
31/07/80		3. 08	95. 51	0. 403	0. 715	38. 46	1. 04	720	8. 1	2. 7	6. 3	0. 0	3. 4	2. 3	4. 5	0. 2	0. 0	5. 4	0. 8	4. 2
01/08/80																				
18/08/80		-	-	-	-	-	1. 02	720	8. 6	2. 3	5. 5	0. 0	3. 2	2. 9	4. 0	0. 2	0. 0	5. 4	1. 4	3. 6
01/09/80																				
22/09/80		3. 22	102. 48	0. 357	0. 551	36. 62	1. 06	750	7. 4	3. 0	7. 0	0. 0	3. 2	2. 4	5. 0	0. 2	0. 0	5. 4	1. 3	4. 1
01/10/80																				
04/10/80		3. 18	100. 49	0. 396	0. 599	39. 76	1. 13	830	7. 3	2. 4	6. 0	0. 4	3. 7	2. 3	4. 2	1. 2	0. 0	6. 4	1. 4	3. 6
27/10/80		3. 09	96. 01	0. 302	0. 536	28. 95	1. 15	760	7. 3	1. 6	3. 9	0. 0	4. 2	3. 3	3. 1	0. 6	0. 0	5. 0	0. 9	5. 3
01/11/80																				
11/11/80		3. 04	93. 52	0. 471	0. 726	44. 03	1. 16	860	7. 8	2. 4	6. 2	0. 0	4. 6	2. 7	4. 6	0. 2	0. 0	7. 0	0. 8	4. 3
24/11/80		3. 10	96. 50	0. 325	0. 522	31. 39	1. 66	1190	7. 4	3. 5	8. 9	0. 0	4. 6	3. 1	6. 9	2. 0	0. 0	6. 4	6. 0	4. 2
01/12/80																				
07/12/80		3. 07	95. 01	0. 318	0. 411	30. 17	1. 47	1040	7. 3	2. 1	5. 6	0. 0	5. 2	4. 8	4. 7	0. 2	0. 0	7. 0	4. 1	3. 8
25/12/80		3. 32	107. 46	0. 373	0. 449	40. 05	1. 40	970	7. 9	4. 4	10. 5	0. 0	3. 2	3. 0	7. 7	0. 1	0. 0	5. 8	3. 7	4. 5
01/01/81																				
07/01/81		3. 03	93. 03	-	0. 486	-	1. 46	1030	7. 0	3. 2	8. 1	0. 0	2. 5	4. 8	6. 1	1. 2	0. 0	6. 6	4. 2	3. 8

2. 4. 3. EB 07, calibration measurement

Date	Waterdepth	Discharge
9/09/81	3. 18	37. 24
21/10/81	3. 24	33. 46
26/01/82	3. 07	28. 47

Regression line : $Q = 0.52\ D^{3.60}$, $R^2 = 0.53$

2. 5. EB 08, Bahr Baqar drain at 'Kubri Bahr Baqar'

2. 5. 1. EB 08, cross section at measurement location

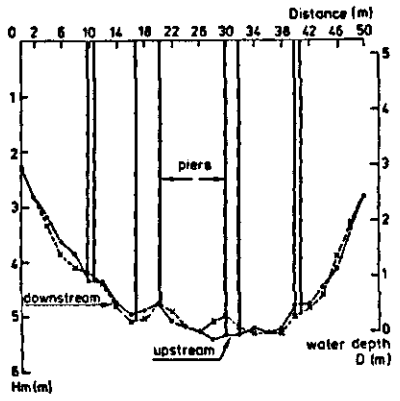


Fig. A 2-5. EB 08, cross section at measurement location

Date of observation : 08/12/80
Depth at reference point : 5. 27 m
Bridge width : 6. 45 m
Cross section width : 50. 00 m

Distance from zero point(m)	Effective section width (m) w	Area cross section (m^2) for Hm = 0; D = 5. 27 A_s
2	4. 00	11. 16
6	4. 00	14. 67
10	3. 20	13. 41
14	4. 00	18. 80
18	3. 60	17. 57
22	3. 60	17. 90
26	4. 00	20. 83
30	3. 20	16. 55
34	4. 00	20. 91
38	3. 60	18. 60
42	3. 60	16. 90
46	4. 00	15. 79
49	2. 00	6. 14

2. 5. 2. EB 08, calculation sheet

Observation year : 1980
Catchment area : Bahr Baqar drain
Measurement point : EB 08
Remarks :

Waterdepth : D = 5. 27 - Hm
Pendulum constant : c_P = _____
Float constant : c_D = _____ + _____ D
Calibration : Q = _____ (D _____) _____

Date	P	D (Hm) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79		3. 16	110. 48	0. 387		42. 75	1. 04	730	7. 2	2. 4	5. 8	0. 0	5. 0	1. 0	4. 2	0. 2	0. 0	5. 5	0. 3	4. 6
01/01/80																				
06/01/80		2. 96	101. 12	0. 369		37. 33	1. 16	790	7. 1	2. 5	6. 2	0. 1	3. 9	2. 6	4. 5	0. 2	0. 0	6. 6	0. 0	4. 6
27/01/80		2. 85	95. 97	0. 363		34. 85	2. 21+		7. 6				8. 7	8. 1	5. 0	0. 2	0. 0	7. 3	9. 1	5. 6
01/02/80																				
10/02/80		2. 73	90. 46	0. 349		31. 49	1. 70	1200	7. 6	3. 6	9. 6	0. 0	5. 2	4. 2	7. 9	0. 2	0. 0	7. 4	3. 4	6. 7
25/02/80		2. 94	100. 19	-		-	1. 02	710	7. 0	2. 0	4. 7	0. 0	3. 7	2. 7	3. 5	0. 2	0. 0	5. 2	2. 0	2. 9
01/03/80																				
09/03/80		2. 87	96. 91	0. 356	0. 448	34. 52	1. 14	780	7. 2	1. 3	3. 3	0. 0	4. 7	3. 8	2. 7	0. 2	0. 0	5. 2	2. 4	3. 8
23/03/80		2. 93	99. 72	0. 190	0. 443	18. 92	1. 66	1230	-	4. 4	11. 9	3. 1	5. 2	2. 5	8. 6	0. 2	0. 0	10. 8	2. 1	3. 6
01/04/80																				
13/04/80		2. 82	94. 57	0. 357	0. 410	33. 77	1. 22	780	7. 2	2. 8	4. 8	0. 0	4. 0	3. 1	5. 3	0. 3	0. 0	1. 2	3. 5	8. 0
20/04/80		2. 69	88. 49	0. 503	0. 505	44. 51	1. 16	800	7. 3	2. 6	6. 5	0. 0	3. 0	3. 6	4. 8	0. 1	0. 0	6. 0	1. 5	4. 0
01/05/80																				
04/05/80		2. 45	77. 37	0. 281	0. 466	21. 72	1. 21	790	7. 2	2. 3	5. 2	0. 0	3. 7	3. 8	4. 5	0. 1	0. 0	3. 2	3. 9	5. 0
26/05/80		2. 81	94. 10	0. 215	0. 428	20. 22	1. 04	720	7. 4	2. 1	5. 1	0. 0	3. 5	2. 7	3. 7	0. 4	0. 0	5. 6	0. 6	4. 1
01/06/80																				
03/06/80		2. 83	95. 04	0. 228	0. 423	21. 64	1. 10	760	7. 3	2. 3	5. 7	0. 0	3. 6	3. 0	4. 2	0. 2	0. 0	6. 0	0. 6	4. 4
15/06/80		2. 77	92. 23	0. 366	0. 505	33. 75	1. 11	770	7. 3	3. 1	7. 3	0. 0	3. 6	2. 1	5. 2	0. 2	0. 0	5. 4	1. 0	4. 7
29/06/80		2. 72	89. 89	0. 312	0. 483	28. 03	1. 11	770	7. 3	3. 1	7. 4	0. 0	3. 6	2. 1	5. 3	0. 1	0. 0	5. 4	1. 0	4. 7
01/07/80																				
16/07/80		2. 74	90. 83	0. 394	0. 530	35. 77	1. 13	850	7. 5	5. 4	12. 4	2. 5	3. 2	0. 8	7. 7	0. 2	0. 0	6. 5	0. 3	5. 1
31/07/80		2. 83	95. 04	0. 445	0. 581	42. 28	1. 09	760	7. 8	2. 6	6. 2	0. 0	3. 9	2. 3	4. 5	0. 2	0. 0	6. 0	0. 5	4. 4
01/08/80																				
18/08/80		2. 88	97. 38	0. 405	0. 492	39. 47	1. 13	820	7. 1	2. 5	5. 9	0. 1	3. 2	2. 1	4. 1	2. 0	0. 0	5. 4	1. 1	4. 9
01/09/80																				
22/09/80		3. 09	107. 21	0. 318	0. 543	34. 12	1. 11	780	7. 6	2. 8	6. 8	0. 0	3. 2	2. 8	4. 9	0. 2	0. 0	5. 8	1. 2	4. 1
01/10/80																				
04/10/80		3. 05	105. 33	0. 348	0. 617	36. 36	1. 15	810	7. 3	2. 0	5. 0	0. 0	4. 2	3. 3	3. 8	0. 2	0. 0	6. 8	0. 7	4. 0
27/10/80		2. 71	89. 42	0. 224	0. 355	20. 04	1. 15	810	7. 4	2. 8	7. 0	0. 0	3. 7	2. 8	5. 1	0. 1	0. 0	6. 1	0. 5	5. 1
01/11/80																				
11/11/80		3. 92	146. 05	0. 407	0. 436	59. 41	1. 18	830	7. 3	1. 5	4. 1	0. 0	4. 0	4. 6	3. 2	0. 2	0. 0	7. 0	0. 7	4. 3
24/11/80		2. 97	101. 59	0. 305	0. 439	31. 02	1. 67	1210	7. 5	2. 9	7. 5	0. 0	5. 4	3. 2	6. 1	2. 2	0. 0	6. 2	6. 1	4. 6
01/12/80																				
07/12/80		2. 92	99. 25	0. 291	0. 370	28. 88	1. 61	1150	7. 1	3. 4	8. 7	0. 0	4. 5	4. 8	7. 3	0. 1	0. 0	6. 0	6. 4	4. 3
25/12/80		3. 05	105. 33	0. 392	0. 442	41. 27	1. 55	1100	8. 0	4. 8	11. 6	0. 0	3. 4	3. 3	8. 7	0. 1	0. 0	6. 0	6. 7	2. 8
01/01/81																				
10/01/81		3. 03	104. 40	0. 340	0. 432	35. 52	1. 44	1010	7. 2	4. 3	10. 4	0. 0	1. 8	4. 7	7. 7	0. 2	0. 0	6. 2	4. 7	3. 5

2. 5. 3. EB 08, calibration measurements

Date	Waterdepth	Discharge
27/09/81	3. 17	43. 63
01/11/81	3. 06	29. 02
07/02/82	2. 79	23. 85

Regression line : $Q = 0.31\ D^{4.20}$, $R^2 = 0.81$

2. 6. EH 02, Hanut pump station

2. 6. 1. EH 02, calibration measurements

Measurement date: 28/10/81

Suction head ΔH (m)	Discharge (m^3/s) unit 1	unit 2	unit 3
2. 05	4. 64		
2. 76	4. 53		
1. 88		5. 13	
2. 65		4. 70	
1. 82			5. 36
2. 44			4. 82

Regression line: Q = 6. 28 - 0. 63 H $m^3 . s^{-1}$, R^2 = 0. 63

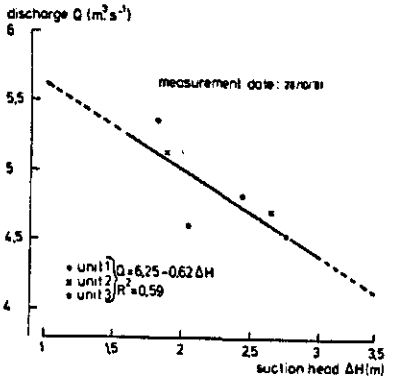


Fig. A 2-6. EH 02, calibration measurements

2. 7. EH 11, Bahr Hadus drain at 'Kubri Bahr Hadus'

2. 7. 1. EH 11, cross section at measurement location

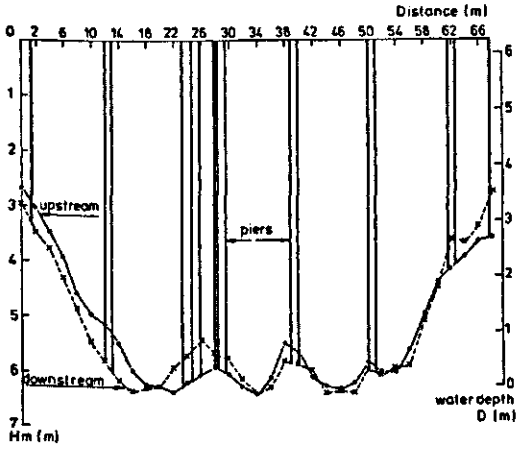


Fig. A 2-7. EH 11, cross section at measurement location

Date of observation : 08/12/80
Depth at reference point : 6. 23 m
Bridge width : 5. 73 m
Cross section width : 68. 00 m

Distance from zero point(m)	Effective section width (m) w	Area cross section(m^2) for Hm = 0; D = 6. 23 A_s
2	3. 70	11. 91
6	4. 00	16. 46
10	3. 70	18. 85
14	3. 70	21. 46
18	4. 00	24. 73
22	3. 70	22. 46
26	3. 10	17. 79
30	3. 40	20. 05
34	4. 00	24. 88
38	3. 40	19. 60
42	4. 00	23. 85
46	4. 00	24. 88
50	3. 40	20. 25
54	4. 00	23. 34
58	4. 00	19. 90
62	3. 40	13. 37
66	3. 70	12. 75

2. 7. 2. EH 11, calculation sheet

Observation year : 1980
Catchment area : Bahr Hadus drain
Measurement point : EH 11
Remarks :

Waterdepth : D = 6.23 - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....)

Date	P	D (gH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79		3.86	186.75	0.511	-	95.47	1.57	970	7.4	3.9	8.9	0.0	5.5	2.2	7.7	0.2	0.0	3.6	0.3	11.7
01/01/80																				
06/01/80		3.71	177.27	0.376	-	66.70	2.52	1550	7.4	5.8	14.0	0.0	4.2	7.0	13.7	0.2	0.0	4.2	4.9	16.0
27/01/80		3.46	161.47	0.298	-	48.18	3.83	2390	7.5	6.9	18.3	0.0	9.5	8.6	20.9	0.2	0.0	5.1	6.8	27.3
01/02/80																				
10/02/80		3.47	162.10	0.218	-	35.33	4.51	2740	7.6	8.0	21.7	0.0	8.9	10.8	25.0	0.2	0.0	6.2	7.5	31.2
25/02/80		3.85	186.11	0.635	1.273	118.11	0.99	670	7.2	1.9	4.3	0.0	3.8	2.5	3.4	0.2	0.0	3.8	2.7	3.4
01/03/80																				
09/03/80		3.75	179.79	0.450	0.522	80.94	1.87	1180	7.7	2.7	6.4	0.0	5.2	6.8	6.5	0.2	0.0	3.6	6.6	8.5
23/03/80		3.57	168.42	0.430	0.422	72.42	2.31	1470	-	4.7	12.7	0.0	5.2	6.4	11.2	0.2	0.0	6.0	0.2	14.8
01/04/80																				
13/04/80		3.72	177.90	0.514	0.476	91.51	2.21	1510	7.4	6.0	16.1	0.0	5.0	4.5	13.0	0.3	0.0	9.2	0.1	13.5
20/04/80		3.71	177.27	0.476	0.470	84.45	2.30	1430	7.7	6.1	14.6	0.0	4.5	4.5	13.0	0.2	0.0	4.4	6.3	11.5
01/05/80																				
04/05/80		3.60	170.31	0.307	0.426	52.20	2.50	1550	7.4	6.6	13.9	0.0	4.7	5.3	14.8	0.2	0.0	2.3	8.2	14.5
26/05/80		3.70	176.63	0.423	0.542	74.65	1.60	1030	7.6	4.3	10.0	0.0	5.0	2.6	8.3	0.1	0.0	4.4	2.0	9.6
01/06/80																				
03/06/80		3.62	171.58	0.376	0.347	64.48	2.22	1500	7.3	4.6	12.6	0.0	3.6	8.0	11.0	0.2	0.0	8.8	2.8	11.2
15/06/80		3.74	179.16	0.518	0.576	92.75	2.38	1520	7.4	7.1	17.4	0.0	4.4	4.4	14.8	0.2	0.0	5.6	3.2	15.0
29/06/80		3.56	167.79	0.289	0.270	48.49	2.09		7.4				3.4	3.4	15.7	0.4	0.0	5.6	2.3	15.0
01/07/80																				
16/07/80		3.88	188.01	0.540	0.523	101.48	2.55	1630	7.2	8.5	20.0	0.0	3.1	4.9	17.0	0.5	0.0	4.8	6.0	14.7
31/07/80		3.93	191.17	0.523	0.561	100.00	2.55	1620	7.8	7.1	17.6	0.0	4.7	4.8	15.5	0.2	0.0	5.4	5.8	14.0
01/08/80																				
18/08/80		3.90	189.27	0.463	0.437	87.55	2.55	1650	7.4	6.8	16.8	0.0	5.0	4.5	14.8	1.1	0.0	5.3	5.8	14.3
01/09/80																				
22/09/80		4.09	201.28	0.439	0.525	88.32	2.46	1560	7.6	6.9	16.5	0.0	4.7	4.8	15.0	0.1	0.0	4.5	5.8	14.3
01/10/80																				
04/10/80		3.33	153.25	0.539	0.465	82.57	2.18	1440	7.4	5.2	13.0	0.0	5.3	4.8	11.6	0.2	0.0	5.4	6.6	9.9
27/10/80		3.77	181.06	0.403	0.418	72.97	2.09	1380	7.8	5.5	14.2	0.0	5.3	3.8	11.8	0.1	0.0	6.7	3.0	11.3
01/11/80																				
11/11/80		3.87	187.38	0.308	0.360	57.78	2.28	1510	7.9	5.0	13.3	0.0	5.4	5.7	11.7	0.2	0.0	7.6	3.4	12.0
24/11/80		3.93	191.17	0.345		66.02	2.73		7.5				6.8	2.3	6.2	0.2	0.0	4.6		20.0
01/12/80																				
07/12/80		3.80	182.95	0.312	0.369	57.00	2.73	1780	7.3	4.7	11.9	0.0	5.8	9.2	13.0	0.2	0.0	4.0	11.7	12.5
25/12/80		3.88	188.01	0.398	0.359	74.87	2.18	1490	8.2	5.6	13.4	0.0	3.9	5.6	12.3	0.2	0.0	4.2	13.1	4.7
01/01/81																				
07/01/81		4.20	208.23	0.425	0.157	88.41	2.18	1410	7.5	4.3	10.5	0.0	1.8	9.5	10.2	0.3	0.0	4.3	10.2	7.3

2. 7. 3. EH 11, calibration measurements

Date	Time	Water depth D(m)	Discharge Q ($m^3 . s^{-1}$) Calibration	Floats	Cross section (m^2) at routine measurement location, A_s	Average velocity Calibration	Floats	Pendulum meter velocity in reference section v_p
08/11/81	13.00	3.71			177.27			0.279
08/11/81	12.30-14.30	3.71	39.61		177.27	0.223		
08/11/81	14.00	3.71			177.27			0.317
08/11/81	14.45	3.71		44.18	177.27		0.249	
02/02/82	14.00	3.45			160.20			0.123
02/02/82	13.30-15.30	3.44	13.56		160.20	0.085		
02/02/82	15.00	3.44			160.20			0.146
02/02/82	16.00	3.44		30.70	160.20		0.192	

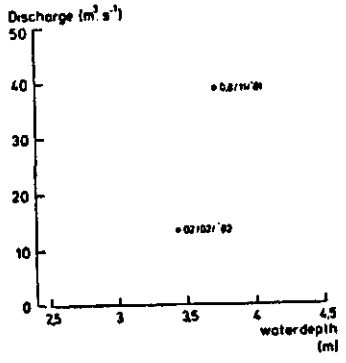


Fig. A 2-8. EH 11, Stage discharge relation

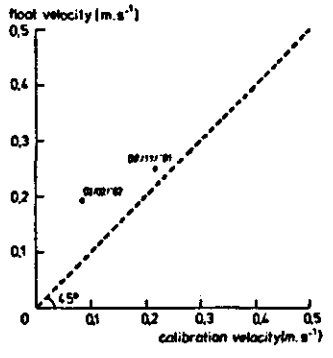


Fig. A 2-9. EH 11, current meter-float relation

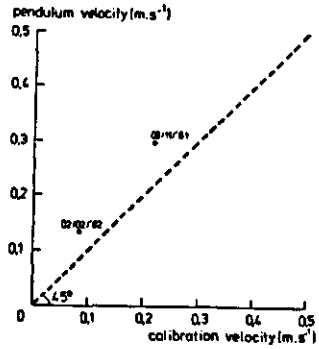


Fig. A 2-10 EH 11, current meter - pendulum meter relation

2. 8. EH 13, Bahr Hadus drain 'outfall'

2. 8. 1. Calculation sheet

Observation year : 1980
Catchment area : Bahr Hadus drain
Measurement point : EH 13
Remarks : Data on discharges of 1979, 1981 and 1982 are also used

Waterdepth : D = 2.86 - Hm
Pendulum constant : c_p = _____
Float constant : c_D = _____ + _____ D
Calibration : Q = _____ (D _____)^____

Date	P	D (à H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q ** (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
07/12/80					0.139															
08/12/79							2.13	1400	7.6	5.7	13.7	0.0	4.4	4.6	12.0	0.2	0.0	4.8	7.9	8.5
25/12/80					0.222															
01/01/80																				
07/01/80					0.148		2.24	1430	8.2	6.8	15.5	0.0	4.8	3.6	13.9	0.2	0.0	3.8	5.2	13.5
28/01/80							4.33	2690	7.6	11.7	29.1	0.0	9.0	4.1	30.0	0.1	0.0	4.9	8.7	29.6
01/02/80		2.19				7.56														
11/02/80							5.78	3520	7.4	11.1	29.4	0.0	11.0	10.4	36.2	0.2	0.0	5.3	11.7	40.8
23/02/81		2.29				40.75														
26/02/80							2.21	1400	7.3	5.0	11.7	0.0	5.0	5.5	11.4	0.2	0.0	3.6	7.0	11.5
01/03/80																				
10/03/80						48.26	2.04	1270	7.3	3.3	8.1	0.0	4.7	7.3	8.2	0.2	0.0	3.6	5.8	11.0
24/03/80							2.64	1710	-	6.1	16.4	0.0	6.3	5.3	14.6	0.2	0.0	8.0	2.7	15.7
01/04/80																				
10/04/79						55.57														
14/04/80							2.47	1440	7.2	5.6	8.6	0.0	5.0	5.9	13.0	0.2	0.0	0.8	6.8	16.5
21/04/80							2.13	1380	7.5	6.5	15.1	0.0	4.0	4.1	13.0	0.1	0.0	4.4	6.3	10.5
01/05/80																				
05/05/80							2.29	1490	7.4	6.1	12.6	0.0	4.2	5.3	13.2	0.2	0.0	2.3	12.6	8.0
19/05/79						53.34														
27/05/80							2.16	1390	7.6	6.3	14.8	0.0	5.0	3.6	13.0	0.0	0.0	4.4	5.2	12.0
01/06/80																				
04/06/80							2.46	1510	7.6	4.8	10.4	0.0	6.2	6.1	12.0	0.3	0.0	2.2	7.4	15.0
16/06/80							2.33	1460	7.1	6.2	15.4	0.0	5.0	4.5	13.6	0.2	0.0	5.2	1.7	16.4
19/06/79						45.09														
01/07/80							2.73	1660	7.1	6.8	16.9	0.0	6.0	4.5	15.6	0.2	0.0	5.2	4.6	16.5
14/07/79						48.89														
16/07/80							2.73	1780	7.3	9.2	21.8	0.0	3.6	4.9	19.0	0.2	0.0	4.8	7.7	15.2
01/08/80							2.82	1800	7.7	6.9	17.4	0.0	6.3	5.2	16.5	0.2	0.0	5.4	6.9	15.9
06/08/80		2.32			0.218	53.94														
18/08/80		2.31			0.190		2.73	1750	7.4	6.6	16.6	0.0	5.2	5.6	15.3	1.1	0.0	5.4	6.2	15.6
01/09/80																				
22/09/80					0.187		2.73	1730	7.5	6.5	16.5	0.0	5.7	5.8	15.7	0.1	0.0	5.2	6.0	16.1
01/10/80																				
04/10/80					0.239		2.46	1620	7.3	10.0	23.6	0.2	3.2	2.8	17.4	1.2	0.0	6.2	3.6	14.8
27/10/80					0.255		2.18	1420	8.0	5.3	13.8	0.0	5.0	5.0	11.9	0.1	0.0	6.6	2.7	12.7
01/11/80																				
11/11/80					0.186		2.46	1600	7.8	5.8	15.5	0.0	5.1	6.0	13.7	0.2	0.0	7.6	2.1	15.3
15/11/81		2.32				46.17														
24/11/80					0.176		3.28	2150	7.4	7.5	18.5	0.0	8.0	4.8	18.9	1.1	0.0	4.5	14.0	14.3
01/12/80																				
07/12/80					0.139		3.19	2020	7.4	7.6	19.0	0.0	5.8	6.2	18.7	0.5	0.0	4.8	12.0	14.4
25/12/80					0.222		2.55	1780	8.1	9.1	21.7	0.0	3.9	3.7	17.8	0.1	0.0	5.4	15.9	4.2
01/01/81																				
07/01/81					0.148		1.15	750	7.1	3.8	8.5	0.0	2.0	3.1	6.1	0.2	0.0	4.5	0.5	6.4

** The discharges are calibration measurements (Annex 1. 8. 5)

2. 9. MG 09, pump station No. 4

2. 9. 1. MG 09, calculation sheet

Observation year : 1980
Catchment area : Gharbia drain
Measurement point : MG 09
Remarks : Waterquality data jan-march from observation year 1981

Waterdepth : D = ... - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						8. 86	2. 28	1530	7. 5	9. 4	21. 1	0. 0	4. 4	1. 8	16. 5	0. 2	0. 0	4. 7	8. 3	9. 9
01/01/80																				
23/01/81						8. 23	2. 09	1390	8. 0	4. 2	10. 3	0. 0	4. 8	6. 3	10. 0	0. 4	0. 0	4. 0	8. 2	9. 3
01/02/80																				
09/02/81						6. 26	6. 44	3930	7. 2	9. 4	28. 0	0. 0	14. 2	14. 2	35. 4	1. 2	0. 0	9. 8	4. 0	51. 3
22/02/81						6. 26	2. 32	1440	7. 0	4. 1	10. 1	0. 0	6. 5	6. 1	10. 3	0. 5	0. 0	4. 0	3. 7	15. 7
01/03/80																				
06/03/81						9. 97	1. 81	1190	7. 6	5. 3	12. 0	0. 0	6. 5	0. 6	10. 0	0. 9	0. 0	4. 0	3. 8	10. 2
21/03/81						9. 97	2. 26	1370	7. 6	6. 2	14. 2	0. 0	3. 8	5. 3	13. 3	0. 2	0. 0	3. 5	2. 2	16. 9
01/04/80																				
04/04/81						10. 62	1. 36	930	8. 2	4. 2	9. 0	0. 0	3. 1	3. 0	7. 3	0. 2	0. 0	3. 3	6. 8	3. 5
16/04/80						10. 62	1. 42	920	7. 4	4. 5	10. 0	0. 0	3. 5	2. 7	8. 0	0. 2	0. 0	3. 8	1. 6	9. 0
01/05/80																				
06/05/80						9. 28	2. 13	1320	7. 8	6. 0	13. 5	0. 0	4. 2	4. 3	12. 3	0. 2	0. 0	3. 6	4. 2	13. 2
20/05/80						9. 28	1. 38	910	7. 4	2. 8	6. 3	0. 0	3. 5	3. 7	5. 3	1. 5	0. 0	3. 6	2. 2	8. 2
01/06/80																				
09/06/80						12. 63	1. 07	710	7. 6	4. 1	8. 7	0. 0	2. 1	2. 4	6. 1	0. 2	0. 0	4. 0	0. 7	6. 1
22/06/80						12. 63	1. 92	1290	7. 7	6. 0	14. 1	0. 0	2. 8	4. 7	11. 6	0. 4	0. 0	4. 8	6. 4	8. 3
01/07/80																				
08/07/80						15. 53	1. 48	960	7. 6	4. 0	9. 3	0. 0	2. 6	4. 6	7. 5	0. 2	0. 0	4. 7	1. 5	8. 7
25/07/80						15. 53	1. 43	960	8. 0	4. 8	11. 2	0. 0	3. 2	2. 8	8. 4	0. 1	0. 0	5. 0	1. 7	7. 8
01/08/80																				
07/08/80						17. 84	1. 27	870	7. 3	3. 6	8. 5	0. 0	4. 7	1. 8	6. 5	0. 1	0. 0	5. 0	0. 9	7. 2
30/08/80						17. 84	1. 32	910	7. 6	5. 4	12. 1	0. 0	3. 2	1. 8	8. 6	0. 1	0. 0	4. 7	1. 4	7. 6
01/09/80																				
14/09/80						14. 46	1. 40	930	7. 6	4. 7	10. 8	0. 0	3. 2	2. 4	7. 9	0. 6	0. 0	4. 8	0. 6	8. 7
27/09/80						14. 46	1. 51	950	7. 6	2. 2	5. 6	0. 0	3. 2	6. 8	4. 9	0. 1	0. 0	5. 4	1. 5	8. 1
01/10/80																				
15/10/80						13. 30	1. 04	710	7. 4	2. 2	5. 1	0. 0	3. 7	2. 8	3. 9	0. 1	0. 0	4. 9	1. 0	4. 6
01/11/80																				
06/11/80						8. 92	1. 40	920	7. 6	3. 6	8. 5	0. 0	5. 5	1. 5	6. 7	0. 3	0. 0	5. 0	0. 4	8. 6
20/11/80						8. 92	1. 40	910	7. 4	1. 6	3. 9	0. 0	3. 9	6. 9	3. 7	0. 2	0. 0	4. 0	2. 4	8. 3
01/12/80																				
30/12/80						10. 40	2. 28	1530	7. 5	9. 4	21. 1	0. 0	4. 4	1. 8	16. 5	0. 2	0. 0	4. 7	8. 3	9. 9
01/01/81																				
23/01/81						8. 86	2. 09	1390	8. 0	4. 2	10. 3	0. 0	4. 8	6. 3	10. 0	0. 4	0. 0	4. 0	8. 2	9. 3

2. 10. MG 10, pump station No. 3

2. 10. 1. MG 10, calculation sheet

Observation year : 1980
Catchment area : Gharbia drain
Measurement point : MG 10
Remarks : Waterquality data jan - march from observation year 1981

Waterdepth : D = ... - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						8. 62	3. 64-		7. 4				4. 8	5. 6	32. 0	0. 6	0. 0	4. 7	16. 2	22. 1
01/01/80																				
23/01/81						7. 67	2. 37	1550	7. 9	7. 4	17. 4	0. 0	4. 8	3. 4	15. 0	0. 4	0. 0	4. 5	7. 8	11. 3
01/02/80																				
09/02/81						6. 05	8. 31	4940	7. 4	13. 1	35. 4	0. 0	11. 7	18. 8	51. 1	1. 4	0. 0	5. 0	14. 2	63. 8
22/02/81						6. 05	2. 26		7. 2				0. 2	2. 3	15. 7	0. 3	0. 0	4. 3		15. 8
01/03/80																				
06/03/81						8. 66	2. 03	1250	7. 8	6. 5	14. 3	0. 0	5. 9	1. 5	12. 5	0. 2	0. 0	3. 5	1. 7	14. 9
21/03/81						8. 66	2. 83-		7. 5				5. 4	6. 0	20. 0	0. 2	0. 0	3. 8	4. 3	23. 5
01/04/80																				
04/04/81						7. 90	1. 92	1240	7. 5	6. 1	13. 6	0. 0	3. 4	4. 4	12. 0	0. 2	0. 0	3. 6	2. 9	13. 5
16/04/80						7. 90	2. 29	1430	7. 6	6. 0	14. 0	0. 0	4. 5	5. 0	13. 0	0. 2	0. 0	4. 0	5. 2	13. 5
01/05/80																				
06/05/80						7. 94	2. 04	1340	7. 7	7. 7	16. 9	0. 0	4. 4	2. 1	13. 8	0. 2	0. 0	4. 0	6. 1	10. 4
20/05/80						7. 94	2. 04	1140	7. 2	5. 5	12. 2	0. 0	2. 7	4. 6	10. 5	0. 4	0. 0	3. 6	3. 1	11. 5
01/06/80																				
09/06/80						13. 14	2. 30	1440	7. 8	7. 8	17. 9	0. 0	2. 6	4. 9	15. 2	0. 3	0. 0	4. 2	3. 8	15. 0
22/06/80						13. 14	2. 83	1810	7. 6	8. 9	21. 0	0. 0	3. 0	6. 2	19. 0	0. 2	0. 0	4. 6	8. 7	15. 1
01/07/80																				
08/07/80						14. 76	2. 73	1730	7. 7	8. 1	19. 5	0. 0	4. 7	4. 8	17. 7	0. 3	0. 0	4. 7	5. 3	17. 5
25/07/80						14. 76	2. 21	1430	7. 6	7. 0	16. 8	0. 0	4. 2	3. 8	14. 0	0. 2	0. 0	5. 1	4. 1	13. 0
01/08/80																				
07/08/80						15. 52	1. 91-		7. 5				4. 2	4. 3	13. 5	0. 2	0. 0	5. 2	4. 0	13. 0
30/08/80						15. 52	2. 00	1290	7. 4	6. 4	15. 2	0. 0	3. 2	4. 4	12. 4	0. 2	0. 0	5. 1	2. 3	12. 8
01/09/80																				
14/09/80						16. 58	2. 73	1760	7. 5	8. 6	20. 7	0. 0	3. 2	5. 6	18. 0	0. 3	0. 0	5. 1	8. 7	13. 3
27/09/80						16. 58	2. 82	1790	7. 6	7. 6	19. 2	0. 0	3. 9	6. 6	17. 5	0. 2	0. 0	5. 6	6. 0	16. 6
01/10/80																				
15/10/80						12. 40	1. 69	1130	7. 6	2. 5	6. 5	0. 0	5. 2	5. 8	5. 8	0. 1	0. 0	6. 4	4. 6	5. 9
01/11/80																				
06/11/80						7. 49	1. 00	650	7. 5	2. 9	6. 1	0. 0	3. 2	1. 8	4. 6	0. 4	0. 0	3. 2	0. 8	5. 9
20/11/80						7. 49	2. 49	1570	7. 2	6. 5	16. 7	0. 0	4. 8	5. 3	14. 6	0. 2	0. 0	6. 4	1. 5	17. 0
01/12/80																				
30/12/80						9. 47	3. 64-		7. 4				4. 8	5. 6	32. 0	0. 6	0. 0	4. 7	16. 2	22. 1
01/01/81																				
23/01/81						8. 62	2. 37	1550	7. 9	7. 4	17. 4	0. 0	4. 8	3. 4	15. 0	0. 4	0. 0	4. 5	7. 8	11. 3

2. 11. WE 10, Edko pump station

2. 11. 1. WE 10, calculation sheet

Observation year : 1980
Catchment area : Edko drain
Measurement point : WE 10
Remarks : Water quality data of Jan-Febr. are from 1981

Waterdepth : D = ... - Hm
Pendulum constant : c_P = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....)

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						-	6.37	4750	7.9	19.0	47.3	0.0	3.7	12.8	54.6	0.7	0.0	4.7	45.3	21.8
01/01/80																				
I/01/80						1.91														
20/01/81						2.45	7.55	5500	7.4	25.5	69.9	0.0	3.8	11.3	70.0	0.9	0.0	10.0	27.4	48.6
III/01/80						1.64														
01/02/80																				
03/02/81						2.18	13.29	9620	8.0	23.2	68.1	0.0	16.4	27.1	108.0	0.9	0.0	8.2	66.2	78.0
08/02/81						2.18	4.75-		7.0				6.5	20.8	28.0	0.7	0.0	7.3	3.2	45.5
II/02/80						1.96														
25/02/81						1.86	5.20-		6.9				6.5	11.4	44.0	0.6	0.0	5.0	6.7	50.8
01/03/80																				
I/03/80						1.42														
12/03/80						2.60	7.82	4900	7.7	19.0	48.7	0.0	6.8	13.2	60.0	1.0	0.0	5.0	14.6	61.4
24/03/80						5.64	3.91	2540	7.2	13.1	35.1	0.0	4.5	5.5	29.4	0.8	0.0	9.6	0.4	30.2
01/04/80																				
09/04/80						4.42	4.93	3450	7.4	14.8	37.0	0.0	4.5	10.2	40.0	0.8	0.0	5.0	15.0	35.5
II/04/80						4.46														
22/04/80						4.62	4.67	2960	7.7	21.8	42.5	0.0	3.2	3.4	39.6	0.6	0.0	2.8	15.0	29.0
01/05/80																				
I/05/80						5.05														
13/05/80						5.47	3.83	2290	7.7	9.4	24.1	0.0	4.7	8.8	24.4	0.4	0.0	5.6	0.8	31.9
21/05/80						4.99	3.74	2280	6.7	9.2	23.7	0.0	7.1	6.4	24.0	0.2	0.0	5.6	1.9	30.2
01/06/80																				
04/06/80						6.35	3.15	1910	7.6	6.9	17.2	0.0	3.8	8.8	17.2	1.8	0.0	4.8	1.4	25.4
14/06/80						6.06	4.30	2580	7.9	10.1	24.4	0.0	3.0	11.7	27.5	1.1	0.0	3.7	6.2	33.4
III/06/80						6.81														
01/07/80																				
02/07/80						8.95	4.00	2630	7.6	10.1	27.5	0.0	5.1	9.3	27.0	0.6	0.0	8.0	6.4	27.6
16/07/80						8.84	3.55	2280	7.8	11.7	29.6	0.0	5.1	4.4	25.5	0.6	0.0	6.8	6.3	22.5
III/07/80						8.93														
01/08/80																				
02/08/80						9.42	3.45	2160	7.7	10.9	27.5	0.0	4.7	5.3	24.3	0.2	0.0	6.5	4.1	23.9
18/08/80						9.09	3.28	2080	7.6	9.9	24.9	0.0	3.7	6.9	22.2	0.6	0.0	6.1	6.4	20.4
III/08/80						8.94														
01/09/80																				
02/09/80						10.28	2.91	1950	7.4	10.4	25.4	0.0	4.6	3.9	21.4	0.4	0.0	5.9	6.5	17.9
18/09/80						10.29	3.28	2070	7.6	10.5	25.8	0.0	3.4	6.1	22.9	0.5	0.0	5.6	5.9	21.4
27/09/80						10.03	3.28	2110	7.7-	7.8	20.8	0.0	4.7	8.3	20.0	0.4	0.0	6.8	6.3	20.3
01/10/80																				
I/10/80						7.09														
13/10/80						5.98	3.55	2200	7.5	8.8	23.8	0.0	4.7	8.3	22.5	0.2	0.0	7.8	1.6	26.3
III/10/80						5.22														
01/11/80																				
02/11/80						5.19	4.00	2510	7.5	9.4	25.5	0.0	4.5	9.5	25.0	1.1	0.0	7.4	6.3	26.4
16/11/80						6.24	4.55	2940	8.0	10.8	27.7	0.0	6.8	8.7	30.0	0.2	0.0	5.3	19.2	21.2
III/11/80						5.41														
01/12/80																				
03/12/80						4.91	5.00	3170	7.4	15.6	37.7	0.0	4.2	7.3	37.5	1.1	0.0	4.8	15.9	29.4
17/12/80						2.60	6.55	4610	7.1	19.5	48.1	0.0	5.2	10.1	54.0	0.8	0.0	4.7	40.7	24.7
30/12/80						-	6.37	4750	7.9	19.0	47.3	0.0	3.7	12.8	54.6	0.7	0.0	4.7	45.3	21.8
01/01/81																				
I/01/81						1.91														
20/01/81						2.45	7.55	5500	7.4	25.5	69.9	0.0	3.8	11.3	70.0	0.9	0.0	10.0	27.4	48.6

2. 12. WE 11, Bosseili pump station

2. 12. 1. WE 11, calculation sheet

Observation year : 1980
Catchment area : Edko drain
Measurement point : WE 11
Remarks : water quality data of Jan. - Febr. are from observation year 1981

Waterdepth : D = ... - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						4. 16	3. 37	2280	7. 6	11. 4	26. 8	0. 0	3. 2	6. 9	25. 6	0. 5	0. 0	4. 3	10. 7	21. 2
01/01/80																				
1/01/80						2. 01														
20/01/81						3. 09	28. 21	20560	7. 0	57. 8	166. 0	0. 0	11. 0	36. 0	280. 0	2. 7	0. 0	8. 5	116. 3	204. 9
III/01/80						1. 93														
01/02/80																				
03/02/81						2. 52	22. 75	14830	7. 6	37. 2	112. 9	0. 0	20. 4	30. 6	188. 0	0. 9	0. 0	10. 8	73. 1	156. 0
08/02/81						2. 53	9. 83-		7. 5				10. 4	16. 4	95. 0	3. 0	0. 0	6. 5	14. 3	104. 0
II/02/80						4. 17														
25/02/81						4. 78	2. 82-		7. 2				4. 6	6. 0	20. 0	0. 5	0. 0	4. 4	3. 4	23. 3
01/03/80																				
I/03/80						4. 69														
12/03/80						8. 23	2. 21	1380	7. 7	8. 4	17. 4	0. 0	3. 0	3. 7	15. 3	0. 3	0. 0	3. 0	3. 5	15. 8
24/03/80						7. 75	2. 21	1460	7. 4	7. 7	19. 3	0. 1	3. 5	3. 6	14. 6	0. 5	0. 0	7. 2	1. 5	13. 5
01/04/80																				
09/04/80						8. 01	2. 55	1590	7. 4	7. 5	17. 4	0. 0	3. 8	5. 3	16. 0	0. 5	0. 0	4. 0	4. 6	17. 0
II/04/80						9. 78														
22/04/80						9. 78	1. 79	1160	7. 9	6. 3	13. 0	0. 0	3. 4	3. 1	11. 4	0. 2	0. 0	2. 8	5. 3	10. 0
01/05/80																				
I/05/80						9. 61														
13/05/80						10. 27	1. 96	1170	7. 9	5. 1	12. 0	0. 0	3. 7	4. 3	10. 2	0. 4	0. 0	4. 4	2. 1	12. 1
21/05/80						6. 08	1. 87	1230	6. 7	4. 2	10. 6	0. 0	7. 4	2. 0	9. 2	0. 2	0. 0	5. 2	3. 5	10. 1
01/06/80																				
04/06/80						9. 06	1. 21	780	7. 4	2. 4	5. 7	0. 0	3. 5	3. 7	4. 6	0. 2	0. 0	4. 4	1. 4	6. 2
14/06/80						8. 87	2. 04	1280	7. 9	4. 0	9. 4	0. 0	5. 0	5. 7	9. 2	0. 5	0. 0	3. 6	5. 4	11. 4
III/06/80						11. 02														
01/07/80																				
02/07/80						10. 71	1. 87	1230	7. 6	5. 5	13. 8	0. 0	4. 1	3. 5	10. 7	0. 4	0. 0	6. 8	0. 4	11. 5
16/07/80						10. 96	1. 41	950	7. 6	4. 7	11. 1	0. 0	2. 0	3. 8	8. 0	0. 3	0. 0	5. 8	1. 4	6. 9
III/07/80						7. 47														
01/08/80																				
02/08/80						7. 28	1. 65	1080	7. 2	5. 3	12. 7	0. 0	3. 2	3. 4	9. 7	0. 2	0. 0	5. 4	1. 7	9. 4
18/08/80						11. 45	1. 57	1040	7. 3	4. 9	11. 6	0. 0	3. 7	2. 8	8. 8	0. 4	0. 0	5. 3	1. 7	8. 7
III/08/80						11. 38														
01/09/80																				
02/09/80						11. 60	1. 53	1010	7. 4	3. 9	9. 6	0. 0	3. 7	3. 8	7. 5	0. 4	0. 0	5. 9	0. 8	8. 7
16/09/80						11. 10	1. 82	1210	7. 8	6. 0	14. 5	0. 0	5. 7	1. 1	11. 0	0. 4	0. 0	6. 0	1. 5	10. 7
27/09/80						9. 18	2. 00	1290	7. 3	5. 4	13. 3	0. 0	4. 2	4. 3	11. 2	0. 3	0. 0	5. 2	3. 5	11. 3
01/10/80																				
I/10/80						10. 87														
13/10/80						5. 61	1. 82	1150	8. 4	5. 0	12. 0	0. 0	4. 2	3. 8	10. 0	0. 2	0. 0	4. 8	1. 2	12. 2
III/10/80						5. 25														
01/11/80																				
02/11/80						3. 63	1. 67	1110	7. 2	5. 0	12. 2	0. 0	3. 7	3. 3	9. 3	0. 4	0. 0	6. 2	1. 6	8. 9
16/11/80						4. 55	2. 18	1450	7. 8	5. 5	13. 3	0. 0	4. 0	5. 5	12. 0	0. 5	0. 0	4. 6	8. 7	8. 7
III/11/80						5. 15														
01/12/80																				
03/12/80						5. 05	2. 00	1350	7. 5	6. 7	15. 5	0. 0	3. 2	3. 9	12. 7	0. 4	0. 0	4. 4	8. 4	7. 4
17/12/80						4. 46	3. 64	2340	7. 1	11. 1	28. 1	0. 0	4. 8	6. 2	26. 0	0. 5	0. 0	6. 2	5. 3	26. 0
30/12/80						4. 16	3. 37	2280	7. 6	11. 4	26. 8	0. 0	3. 2	6. 9	25. 6	0. 5	0. 0	4. 3	10. 7	21. 2
01/01/81																				
I/01/81						2. 01														
20/01/81						3. 09	28. 21	20560	7. 0	57. 8	166. 0	0. 0	11. 0	36. 0	280. 0	2. 7	0. 0	8. 5	116. 3	204. 9

ANNEX 3: DATA SHEETS OPEN DRAINS AFTER CORRECTION FOR RANDOM AND SYSTEMATIC ERROR IN DISCHARGE

3. 1. FB 03, Batts drain at Furgus
3. 2. FB 04, Roda drain
3. 3. FB 05, Batts drain at Tamya
3. 4. EB 07, Bahr Baqar drain at 'Kubri Saud'
3. 5. EB 08, Bahr Baqar drain at 'Kubri Bahr Baqar'
3. 6. EH 11, Bahr Hadus drain at 'Kubri Bahr Hadus'
3. 7. EH 13, Bahr Hadus drain at 'Outfall'

3. 1. FB 03, calculation sheet after correction for random and systematic error in discharge

Observation year : 1980
Catchment area : Batta drain
Measurement point : FB 03
Remarks :

Waterdepth : D = 3.88 - Hm
Pendulum constant : c_P = 0.630
Float constant : c_D = 0.879 + ... D
Calibration : Q = ... (D .....)

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79		1.40	11.06	0.273	-	2.65	1.18	800	8.0	3.3	7.8	0.0	3.1	2.7	5.6	0.3	0.0	5.5	0.6	5.6
01/01/80																				
09/01/80		1.58	12.86	0.936	-	3.80	1.45	940	8.3	2.7	6.4	0.0	3.6	5.3	5.6	0.1	0.0	4.2	3.4	7.0
23/01/80		0.51	3.08	0.198	-	0.54	3.85-		7.4				6.6	10.1	35.0	0.7	0.0	5.3	17.0	30.1
01/02/80																				
06/02/80		0.46	2.78	0.233	-	0.57	4.17	3140	7.4	8.8	25.3	0.0	8.5	11.7	28.0	0.7	0.0	8.8	16.1	24.0
24/02/80		1.69	13.96	0.346	-	4.25	0.94	640	7.6	3.7	7.5	0.0	2.6	1.	5.2	0.4	0.0	3.5	0.8	5.3
01/03/80																				
14/03/80		1.16	8.66	0.367	-	2.79	1.43	950	7.8	3.3	8.1	0.0	4.5	3.1	6.5	0.1	0.0	5.2	2.8	6.2
01/04/80																				
04/04/80		1.08	7.86	0.470	-	3.25	1.28	870	7.5	4.5	9.6	0.0	4.0	1.2	7.3	0.3	0.0	3.5	3.9	5.4
18/04/80		1.08	7.86	0.409	0.622	2.71	1.45	990	7.4	4.9	10.9	0.0	3.0	3.2	8.6	0.2	0.0	4.0	4.0	7.0
30/04/80		1.11	8.16	0.452	0.698	3.16	1.22	810	7.6	4.4	9.6	0.0	2.6	2.4	7.0	0.2	0.0	4.0	2.2	6.0
01/05/80																				
18/05/80		1.03	7.36	0.451	0.762	3.11	1.51	1000	8.0	5.3	11.7	0.0	3.0	2.7	9.0	0.3	0.0	4.0	4.4	6.6
01/06/80																				
02/06/80		0.85	5.56	0.380	-	1.86	1.24	840	7.8	4.3	9.8	0.0	3.8	1.4	7.0	0.2	0.0	4.8	1.0	6.6
28/06/80		0.94	6.46	0.428	0.597	2.14	1.33	900	7.3	3.8	8.7	0.0	4.5	1.8	6.7	0.3	0.0	4.4	3.3	5.6
01/07/80																				
11/07/80		0.86	5.66	0.383	0.579	1.82	1.78	1260	7.7	7.9	17.1	0.0	3.6	1.8	13.0	0.2	0.0	4.1	7.6	6.9
25/07/80		1.02	7.26	0.345	0.540	2.17	0.98-		7.5				3.2	2.4	7.8	0.2	0.0	2.1	5.8	5.7
01/08/80																				
01/09/80																				
17/09/80		1.38	10.86	0.313	0.568	3.42	1.31	910	7.6	4.9	11.3	0.8	3.2	1.8	7.7	0.4	0.0	5.8	1.2	6.1
01/10/80																				
11/10/80		1.22	9.26	0.291	0.478	2.45	1.66	1130	7.9	5.0	12.5	0.0	3.7	3.3	9.3	0.2	0.0	7.0	2.1	7.4
01/11/80																				
04/11/80		0.91	6.16	0.338	0.528	1.80	1.68	1180	7.9	5.3	13.4	0.0	3.7	3.3	10.0	0.2	0.0	7.0	2.8	7.4
09/11/80		1.12	8.26	0.308	0.475	2.17	1.58	1070	7.8	4.8	11.7	0.0	3.9	2.8	8.7	0.2	0.0	6.4	3.0	6.2
01/12/80																				
17/12/80		1.21	9.16	0.353	0.598	3.03	2.00	1380	7.3	5.9	13.0	0.0	4.2	3.8	11.7	0.4	0.0	3.4	13.5	3.2
01/01/81																				
17/01/81		1.16	8.66	0.375	0.624	2.99	2.37	1490	7.3	5.4	13.3	0.0	4.6	6.3	12.5	0.2	0.0	4.8	5.0	13.8

3. 2. EB 07, calculation sheet after correction for random and systematic error in discharge

Observation year : 1980
Catchment area : Batta drain
Measurement point : FB 04
Remarks :

Waterdepth : D = 4.04 - Hm
Pendulum constant : c_P = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....)

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
17/12/80*		0.93	6.01	0.668		4.01	2.18	1530	7.2	8.3	18.2	0.0	3.2	3.4	15.0	0.4	0.0	4.0	14.3	3.7
01/01/80																				
09/01/80		0.55	3.35	0.865		2.90	2.47	1590	8.4	5.4	13.5	0.0	5.4	6.1	13.0	0.2	0.0	4.7	8.7	11.3
23/01/80		0.01	0.45	0.264		0.12	8.42	5980	7.4	16.8	49.3	0.0	6.8	23.1	65.0	0.7	0.0	9.3	33.2	53.1
01/02/80																				
06/02/80		-0.02	0.33	0.454		0.15	8.25	6160	7.6	18.2	49.6	0.0	14.8	13.4	68.5	0.6	0.0	5.8	40.1	51.4
24/02/80		0.67	4.19	1.143		4.79	1.87	1250	7.6	4.9	11.7	0.0	5.2	3.3	10.2	0.4	0.0	4.4	5.6	9.1
01/03/80																				
14/03/80		0.44	2.65	1.159		3.07	2.13	14.00	7.9	3.7	10.1	0.0	5.0	6.9	9.1	0.2	0.0	7.2	4.9	9.1
01/04/80																				
04/04/80		0.44	2.65	1.014		2.69	1.87	1240	7.5	4.9	11.6	0.0	5.0	3.2	10.0	0.4	0.0	4.2	7.2	7.2
18/04/80		0.50	3.01	0.901		2.71	1.42	930	7.4	4.9	10.8	0.0	3.0	2.7	8.3	0.2	0.0	4.0	2.7	7.5
30/04/80		0.51	3.07	0.901		2.77	1.44	970	7.6	6.5	13.7	0.0	2.6	1.9	9.8	0.2	0.0	4.0	3.3	7.2
01/05/80																				
18/05/80		0.45	2.71	0.911		2.47	1.48	970	7.9	5.2	12.0	0.0	3.0	2.7	8.8	0.2	0.0	5.2	1.0	8.5
01/06/80																				
02/06/80		0.15	1.15	0.807		0.93	2.38	1570	7.9	7.0	17.2	0.0	5.4	3.4	14.6	0.3	0.0	5.6	7.5	10.6
28/06/80		0.20	1.40	0.675		0.95	2.72	1770	7.4	8.2	19.8	0.0	4.7	4.5	17.6	0.4	0.0	5.0	9.0	13.2
01/07/80																				
11/07/80		0.22	1.50	1.112		1.67	2.81	1820	7.4	10.5	23.9	0.0	4.2	3.0	20.0	0.4	0.0	4.5	10.2	12.9
25/07/80		0.35	2.15	0.777		1.67	2.73+		7.4				4.7	4.3	16.2	0.2	0.0	4.4	8.5	12.5
01/08/80																				
01/09/80																				
17/09/80		0.95	6.15	0.587		3.61	2.28	1520	7.7	8.2	19.0	0.0	4.2	2.8	15.4	0.4	0.0	4.8	8.3	9.7
01/10/80																				
11/10/80		0.90	5.80	0.686		3.98	2.18	1490	8.0	6.2	15.8	0.0	5.8	3.0	13.0	0.2	0.0	6.7	6.2	9.1
01/11/80																				
04/11/80		0.76	4.82	0.691		3.33	2.22	1520	8.0	6.4	16.4	0.0	5.8	3.0	13.5	0.2	0.0	6.7	6.7	9.1
09/11/80		0.75	4.75	0.742		3.52	2.27	1530	7.9	6.3	15.9	0.0	5.5	3.5	13.3	0.4	0.0	6.4	7.2	9.1
01/12/80																				
17/12/80		0.93	6.01	0.668		4.01	2.18	1530	7.2	8.3	18.2	0.0	3.2	3.4	15.0	0.4	0.0	4.0	14.3	3.7
01/01/81																				
17/01/81		0.88	5.66	0.661		3.74	2.73-		7.2				5.9	3.6	22.0	0.4	0.0	4.8	8.5	18.6

3. 3. FB 05, calculation sheet after correction for random and systematic error in discharge

Observation year : 1980
Catchment area : Batta drain
Measurement point : FB 05
Remarks :

Waterdepth : D = 4. 72 - Hm
Pendulum constant : c_p = ...
Float constant : c_D = 1. 559 - 0. 472 D
Calibration : Q = ... (D .....)

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79		1. 24	7. 61	1. 207		8. 95	1. 31	890	8. 0	3. 1	7. 5	0. 0	4. 0	3. 2	5. 8	0. 2	0. 0	5. 5	1. 6	6. 1
01/01/80																				
09/01/80		1. 17	7. 13	1. 262		9. 06	1. 87	1240	8. 6	5. 4	12. 9	0. 0	4. 2	3. 6	10. 6	0. 3	0. 0	5. 1	5. 1	8. 5
23/01/80		0. 33	1. 52	0. 618		1. 32	5. 70	3460	7. 8	11. 0	27. 9	0. 0	6. 6	13. 7	35. 0	0. 6	0. 0	4. 2	19. 7	32. 0
01/02/80																				
06/02/80		0. 22	0. 97	0. 863		1. 22	11. 82	8250	7. 7	29. 7	82. 5	0. 0	12. 7	10. 0	100. 0	0. 3	0. 0	8. 6	78. 4	36. 0
24/02/80		1. 31	8. 09	1. 332		10. 14	0. 95	660	7. 1	3. 8	7. 0	0. 0	3. 7	0. 4	5. 5	0. 3	0. 0	2. 3	2. 3	5. 3
01/03/80																				
14/03/80		0. 93	5. 47	1. 215		7. 45	1. 96	1300	7. 4	4. 4	11. 7	0. 0	4. 0	5. 5	9. 6	0. 3	0. 0	8. 0	2. 3	9. 1
01/04/80																				
04/04/80		1. 00	5. 95	1. 720		11. 13	1. 02	730	7. 6	3. 9	8. 4	0. 1	3. 5	0. 8	5. 7	0. 3	0. 0	4. 4	2. 1	3. 8
18/04/80		1. 02	6. 09	1. 308		8. 59	1. 45	960	7. 4	5. 1	11. 2	0. 0	3. 5	2. 2	8. 6	0. 2	0. 0	4. 0	3. 0	7. 5
30/04/80		1. 06	6. 37	1. 359		9. 17	1. 29	860	7. 3	4. 4	9. 7	0. 0	2. 9	2. 6	7. 3	0. 2	0. 0	4. 0	2. 4	6. 6
01/05/80																				
18/05/80		0. 83	4. 78	1. 344		7. 50	1. 34	860	7. 9	3. 5	8. 0	0. 0	3. 5	3. 2	6. 4	0. 2	0. 0	4. 0	1. 6	7. 7
01/06/80																				
02/06/80		0. 59	3. 12	1. 286		5. 14	1. 59	1040	8. 0	3. 2	7. 8	0. 0	4. 9	3. 9	6. 8	0. 2	0. 0	4. 4	4. 4	7. 0
28/06/80		0. 70	3. 88	1. 080		5. 15	2. 04	1360	7. 4	6. 2	14. 9	0. 0	4. 2	3. 6	12. 3	0. 4	0. 0	5. 0	6. 1	9. 4
01/07/80																				
11/07/80		0. 70	3. 88	1. 130		5. 39	2. 29	1530	7. 6	11. 3	23. 2	0. 0	3. 1	1. 8	17. 7	0. 3	0. 0	3. 8	9. 4	9. 7
25/07/80		0. 92	5. 40	1. 055		6. 41	2. 09+		7. 8				2. 6	2. 4	11. 0	0. 1	0. 0	4. 8	2. 5	8. 8
01/08/80																				
01/09/80																				
17/09/80		1. 32	8. 16	1. 098		8. 39	1. 91	1280	7. 8	7. 4	16. 8	0. 0	3. 7	2. 3	12. 8	0. 2	0. 0	4. 8	6. 0	8. 2
01/10/80																				
11/10/80		1. 24	7. 61	1. 122		8. 32	1. 91	1350	7. 7	5. 5	14. 0	0. 0	3. 7	4. 8	11. 3	0. 2	0. 0	6. 7	5. 6	7. 7
01/11/80																				
04/11/80		1. 09	6. 57	0. 953		6. 54	1. 94	1400	7. 7	5. 8	14. 8	0. 0	3. 7	4. 8	12. 0	0. 2	0. 0	6. 7	6. 3	7. 7
09/11/80		1. 11	6. 71	0. 993		6. 90	2. 00	1380	8. 4	6. 3	15. 8	0. 0	4. 5	3. 0	12. 2	0. 4	0. 0	7. 0	4. 9	8. 2
01/12/80																				
17/12/80		1. 30	8. 02	1. 029		7. 80	2. 00	1400	7. 4	6. 8	15. 5	0. 0	3. 7	3. 3	12. 7	0. 4	0. 0	4. 4	12. 0	3. 7
01/01/81																				
17/01/81		1. 32	8. 16	1. 029		7. 86	2. 46	1560	7. 2	7. 9	18. 8	0. 0	3. 6	4. 6	16. 0	0. 4	0. 0	5. 0	4. 2	15. 4

3. 4. EB 07, calculation sheet after correction for random and systematic error in discharge

Observation year : 1980
Catchment area : Bahr baqar drain
Measurement point : EB 07
Remarks :

Waterdepth : D = 5. 02 - Hm
Pendulum constant : c_p = ...
Float conetant : c_D = - 1. 23 + 0. 667 D
Calibration : Q = ... (D .....)

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79		3. 27	104. 97	0. 424		42. 26	1. 02	730	7. 1	3. 2	7. 3	0. 3	4. 4	0. 6	5. 0	0. 2	0. 0	5. 3	0. 8	4. 1
01/01/80																				
06/01/80		3. 04	93. 52	0. 387		28. 82	1. 18	820	7. 2	3. 1	7. 3	0. 0	3. 6	2. 4	5. 4	0. 3	0. 0	5. 1	2. 8	3. 8
27/01/80		2. 92	87. 54	0. 453		28. 40	1. 46	1010	7. 6	3. 0	7. 6	0. 0	4. 6	3. 8	6. 1	0. 1	0. 0	7. 7	0. 8	6. 1
01/02/80																				
10/02/80		2. 74	79. 04	0. 382		18. 00	1. 45	970	7. 6	2. 9	7. 4	0. 0	4. 7	3. 3	5. 7	0. 2	0. 0	7. 4	1. 2	5. 3
25/02/80		3. 05	94. 01	0. 448	0. 607	33. 81	1. 79	1180	7. 2	7. 1	16. 1	0. 0	3. 7	2. 0	12. 0	0. 2	0. 0	4. 9	3. 4	9. 6
01/03/80																				
09/03/80		2. 96	89. 53	0. 460	0. 562	30. 59	1. 17	780	7. 7	0. 5	1. 4	0. 0	5. 2	5. 2	1. 2	0. 2	0. 0	5. 2	2. 3	4. 3
23/03/80		2. 91	87. 04	0. 313	0. 554	19. 32	1. 45	1080	-	3. 7	9. 9	3. 5	3. 7	3. 6	7. 0	0. 2	0. 0	10. 8	0. 1	3. 6
01/04/80																				
13/04/80		2. 84	83. 66	0. 447	0. 522	24. 79	1. 16	770	7. 5	2. 8	4. 7	0. 0	3. 5	3. 1	5. 1	0. 3	0. 0	1. 2	5. 8	5. 0
20/04/80		2. 81	82. 22	0. 532	0. 827	28. 12	1. 12	800	7. 3	3. 3	7. 9	0. 7	3. 0	2. 7	5. 5	0. 1	0. 0	6. 4	0. 9	4. 0
01/05/80																				
04/05/80		2. 81	82. 22	0. 397	0. 543	20. 98	1. 22	820	7. 2	3. 9	8. 3	0. 0	3. 2	2. 4	6. 6	0. 1	0. 0	3. 2	4. 1	5. 0
26/05/80		2. 88	85. 57	0. 313	0. 539	18. 47	1. 00	700	7. 4	1. 7	4. 1	0. 0	3. 2	3. 4	3. 0	0. 4	0. 0	5. 6	1. 0	3. 4
01/06/80																				
03/06/80		2. 90	86. 54	0. 388	0. 537	23. 60	1. 07	760	7. 0	2. 5	6. 2	1. 1	2. 6	3. 5	4. 3	0. 2	0. 0	7. 2	0. 0	3. 5
15/06/80		2. 86	84. 61	0. 465	0. 725	26. 60	1. 04	710	7. 4	2. 3	5. 5	0. 0	4. 4	1. 7	4. 0	0. 2	0. 0	5. 2	0. 4	4. 7
29/06/80		2. 88	85. 57	0. 464	0. 684	27. 38	1. 13	710	7. 4	2. 3	5. 5	0. 0	4. 4	1. 7	4. 0	0. 2	0. 0	5. 2	0. 4	4. 7
01/07/80																				
16/07/80		2. 95	89. 03	0. 402	0. 661	26. 35	1. 20	820	7. 3	5. 7	11. 7	0. 1	2. 2	1. 8	8. 0	0. 2	0. 0	4. 1	1. 8	6. 3
31/07/80		3. 08	95. 51	0. 403	0. 715	31. 67	1. 04	720	8. 1	2. 7	6. 3	0. 0	3. 4	2. 3	4. 5	0. 2	0. 0	5. 4	0. 8	4. 2
01/08/80																				
18/08/80		-	-	-	-	-	1. 02	720	8. 6	2. 3	5. 5	0. 0	3. 2	2. 9	4. 0	0. 2	0. 0	5. 4	1. 4	3. 6
01/09/80																				
22/09/80		3. 22	102. 48	0. 357	0. 551	33. 52	1. 06	750	7. 4	3. 0	7. 0	0. 0	3. 2	2. 4	5. 0	0. 2	0. 0	5. 4	1. 3	4. 1
01/10/80																				
04/10/80		3. 18	100. 49	0. 396	0. 599	35. 40	1. 13	830	7. 3	2. 4	6. 0	0. 4	3. 7	2. 3	4. 2	1. 2	0. 0	6. 4	1. 4	3. 6
27/10/80		3. 09	96. 01	0. 302	0. 536	24. 05	1. 15	760	7. 3	1. 6	3. 9	0. 0	4. 2	3. 3	3. 1	0. 6	0. 0	5. 0	0. 9	5. 3
01/11/80																				
11/11/80		3. 04	93. 52	0. 471	0. 726	35. 07	1. 16	860	7. 8	2. 4	6. 2	0. 0	4. 6	2. 7	4. 6	0. 2	0. 0	7. 0	0. 8	4. 3
24/11/80		3. 10	96. 50	0. 325	0. 522	26. 23	1. 66	1190	7. 4	3. 5	8. 9	0. 0	4. 6	3. 1	6. 9	2. 0	0. 0	6. 4	6. 0	4. 2
01/12/80																				
07/12/80		3. 07	95. 01	0. 318	0. 411	24. 66	1. 47	1040	7. 3	2. 1	5. 6	0. 0	5. 2	4. 8	4. 7	0. 2	0. 0	7. 0	4. 1	3. 8
25/12/80		3. 32	107. 46	0. 373	0. 449	39. 40	1. 40	970	7. 9	4. 4	10. 5	0. 0	3. 2	3. 0	7. 7	0. 1	0. 0	5. 8	3. 7	4. 5
01/01/81																				
07/01/81		3. 03	93. 03	-	0. 486	24. 02	1. 46	1030	7. 0	3. 2	8. 1	0. 0	2. 5	4. 8	6. 1	1. 2	0. 0	6. 6	4. 2	3. 8

3. 5. EB 08, calculation sheet after correction for random and systematic error in discharge

Observation year : 1980
Catchment area : Bahr Baqar drain
Measurement point : EB 08
Remarks :

Waterdepth : D = 5. 27 - Hm
Pendulum constant : c_p = 0. 715
Float constant : c_D = - 0. 93 + 0. 598 D
Calibration : Q = ... (D .....) .....

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79																				
01/01/80		3. 16	110. 48	0. 387		41. 11	1. 04	730	7. 2	2. 4	5. 8	0. 0	5. 0	1. 0	4. 2	0. 2	0. 0	5. 5	0. 3	4. 6
06/01/80		2. 96	101. 12	0. 369		33. 71	1. 16	790	7. 1	2. 5	6. 2	0. 1	3. 9	2. 6	4. 5	0. 2	0. 0	6. 6	0. 0	4. 6
27/01/80		2. 85	95. 97	0. 363		27. 03	2. 21+		7. 6				8. 7	8. 1	5. 0	0. 2	0. 0	7. 3	9. 1	5. 6
01/02/80																				
10/02/80		2. 73	90. 46	0. 349		22. 23	1. 70	1200	7. 6	3. 6	9. 6	0. 0	5. 2	4. 2	7. 9	0. 2	0. 0	7. 4	3. 4	6. 7
25/02/80		2. 94	100. 19	-		-	1. 02	710	7. 0	2. 0	4. 7	0. 0	3. 7	2. 7	3. 5	0. 2	0. 0	5. 2	2. 0	2. 9
01/03/80																				
09/03/80		2. 87	96. 91	0. 356	0. 448	24. 46	1. 14	780	7. 2	1. 3	3. 3	0. 0	4. 7	3. 8	2. 7	0. 2	0. 0	5. 2	2. 4	3. 8
23/03/80		2. 93	99. 72	0. 190	0. 443	26. 02	1. 66	1230	-	4. 4	11. 9	3. 1	5. 2	2. 5	8. 6	0. 2	0. 0	10. 8	2. 1	3. 6
01/04/80																				
13/04/80		2. 82	94. 57	0. 357	0. 410	21. 02	1. 22	780	7. 2	2. 8	4. 8	0. 0	4. 0	3. 1	5. 3	0. 3	0. 0	1. 2	3. 5	8. 0
20/04/80		2. 69	88. 49	0. 503	0. 505	21. 74	1. 16	800	7. 3	2. 6	6. 5	0. 0	3. 0	3. 6	4. 8	0. 1	0. 0	6. 0	1. 5	4. 0
01/05/80																				
04/05/80		2. 45	77. 37	0. 281	0. 4b6	13. 84	1. 21	790	7. 2	2. 3	5. 2	0. 0	3. 7	3. 8	4. 5	0. 1	0. 0	3. 2	3. 9	5. 0
26/05/80		2. 81	94. 10	0. 215	0. 428	21. 66	1. 04	720	7. 4	2. 1	5. 1	0. 0	3. 5	2. 7	3. 7	0. 4	0. 0	5. 6	0. 6	4. 1
01/06/80																				
03/06/80		2. 83	95. 04	0. 228	0. 423	21. 96	1. 10	760	7. 3	2. 3	5. 7	0. 0	3. 6	3. 0	4. 2	0. 2	0. 0	6. 0	0. 6	4. 4
15/06/80		2. 77	92. 23	0. 366	0. 505	24. 25	1. 11	770	7. 3	3. 1	7. 3	0. 0	3. 6	2. 1	5. 2	0. 2	0. 0	5. 4	1. 0	4. 7
29/06/80		2. 72	89. 89	0. 312	0. 483	21. 68	1. 11	770	7. 3	3. 1	7. 4	0. 0	3. 6	2. 1	5. 3	0. 1	0. 0	5. 4	1. 0	4. 7
01/07/80																				
16/07/80		2. 74	90. 83	0. 394	0. 530	24. 45	1. 13	850	7. 5	5. 4	12. 4	2. 5	3. 2	0. 8	7. 7	0. 2	0. 0	6. 5	0. 3	5. 1
31/07/80		2. 83	95. 04	0. 445	0. 581	30. 17	1. 09	760	7. 8	2. 6	6. 2	0. 0	3. 9	2. 3	4. 5	0. 2	0. 0	6. 0	0. 5	4. 4
01/08/80																				
18/08/80		2. 88	97. 38	0. 405	0. 492	27. 20	1. 13	820	7. 1	2. 5	5. 9	0. 1	3. 2	2. 1	4. 1	2. 0	0. 0	5. 4	1. 1	4. 9
01/09/80																				
22/09/80		3. 09	107. 21	0. 318	0. 543	38. 28	1. 11	780	7. 6	2. 8	6. 8	0. 0	3. 2	2. 8	4. 9	0. 2	0. 0	5. 8	1. 2	4. 1
01/10/80																				
04/10/80		3. 05	105. 33	0. 348	0. 617	41. 62	1. 15	810	7. 3	2. 0	5. 0	0. 0	4. 2	3. 3	3. 8	0. 2	0. 0	6. 6	0. 7	4. 0
27/10/80		2. 71	89. 42	0. 224	0. 355	15. 71	1. 15	810	7. 4	2. 8	7. 0	0. 0	3. 7	2. 8	5. 1	0. 1	0. 0	6. 1	0. 5	5. 1
01/11/80																				
11/11/80		3. 92	146. 05	0. 407	0. 436	64. 48	1. 18	830	7. 3	1. 5	4. 1	0. 0	4. 0	4. 6	3. 2	0. 2	0. 0	7. 0	0. 7	4. 3
24/11/80		2. 97	101. 59	0. 305	0. 439	27. 04	1. 67	1210	7. 5	2. 9	7. 5	0. 0	5. 4	3. 2	6. 1	2. 2	0. 0	6. 2	6. 1	4. 6
01/12/80																				
07/12/80		2. 92	99. 25	0. 291	0. 370	21. 48	1. 61	1150	7. 1	3. 4	8. 7	0. 0	4. 5	4. 8	7. 3	0. 1	0. 0	6. 0	6. 4	4. 3
25/12/80		3. 05	105. 33	0. 392	0. 442	29. 82	1. 55	1100	8. 0	4. 8	11. 6	0. 0	3. 4	3. 3	8. 7	0. 1	0. 0	6. 0	6. 7	2. 8
01/01/81																				
10/01/81		3. 03	104. 40	0. 340	0. 432	28. 50	1. 44	1010	7. 2	4. 3	10. 4	0. 0	1. 8	4. 7	7. 7	0. 2	0. 0	6. 2	4. 7	3. 5

3. 6. EH 11, calculation sheet after correction dor random and systematic error in discharge

Observation year : 1980
Catchment area : Bahr Hadus drain
Measurement point : EH 11
Remarks :

Waterdepth : D = 6. 23 - Hm
Pendulum constant : c_p = 0. 949
Float constant : c_D = 0. 437 + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79																				
01/01/80		3. 86	186. 75	0. 511	-	41. 70	1. 57	970	7. 4	3. 9	8. 9	0. 0	5. 5	2. 2	7. 7	0. 2	0. 0	3. 6	0. 3	11. 7
06/01/80		3. 71	177. 27	0. 376	-	29. 13	2. 52	1550	7. 4	5. 8	14. 0	0. 0	4. 2	7. 0	13. 7	0. 2	0. 0	4. 2	4. 9	16. 0
27/01/80		3. 46	161. 47	0. 298	-	21. 03	3. 83	2390	7. 5	6. 9	18. 3	0. 0	9. 5	8. 6	20. 9	0. 2	0. 0	5. 1	6. 8	27. 3
01/02/80																				
10/02/80		3. 47	162. 10	0. Z18	-	15. 44	4. 51	2740	7. 6	8. 0	21. 7	0. 0	8. 9	10. 8	25. 0	0. 2	0. 0	6. 2	7. 5	31. 2
25/02/80		3. 85	186. 11	0. 635	0. 670	51. 70	0. 99	670	7. 2	1. 9	4. 3	0. 0	3. 8	2. 5	3. 4	0. 2	0. 0	3. 8	2. 7	3. 4
01/03/80																				
09/03/80		3. 75	179. 79	0. 450	0. 522	38. 92	1. 87	1180	7. 7	2. 7	6. 4	0. 0	5. 2	6. 8	6. 5	0. 2	0. 0	3. 6	6. 6	8. 5
23/03/80		3. 57	168. 42	0. 430	0. 422	29. 47	2. 31	1470	-	4. 7	12. 7	0. 0	5. 2	6. 4	11. 2	0. 2	0. 0	8. 0	0. 2	14. 8
01/04/80																				
13/04/80		3. 72	177. 90	0. 514	0. 476	35. 12	2. 21	1510	7. 4	6. 0	16. 1	0. 0	5. 0	4. 5	13. 0	0. 3	0. 0	9. 2	6. 3	13. 5
20/04/80		3. 71	177. 27	0. 476	0. 470	34. 55	2. 30	1430	7. 7	6. 1	14. 6	0. 0	4. 5	4. 5	13. 0	0. 2	0. 0	4. 4	6. 3	11. 5
01/05/80																				
04/05/80		3. 60	170. 31	0. 307	0. 426	30. 09	2. 50	1550	7. 4	6. 6	13. 9	0. 0	4. 7	5. 3	14. 8	0. 2	0. 0	2. 3	8. 2	14. 5
26/05/80		3. 70	176. 63	0. 423	0. 542	39. 70	1. 60	1030	7. 6	4. 3	10. 0	0. 0	5. 0	2. 6	8. 3	0. 1	0. 0	4. 4	2. 0	9. 6
01/06/80																				
03/06/80		3. 62	171. 58	0. 376	0. 347	24. 69	2. 22	1500	7. 3	4. 6	12. 6	0. 0	3. 6	8. 0	11. 0	0. 2	0. 0	8. 8	2. 8	11. 2
15/06/80		3. 74	179. 16	0. 518	0. 576	42. 80	2. 38	1520	7. 4	7. 1	17. 4	0. 0	4. 4	4. 4	14. 8	0. 2	0. 0	5. 6	3. 2	15. 0
29/06/80		3. 56	167. 79	0. 289	0. 270	18. 79	2. 09-		7. 4				3. 4	3. 4	15. 7	0. 4	0. 0	5. 6	2. 3	15. 0
01/07/80																				
16/07/80		3. 88	188. 01	0. 540	0. 523	40. 78	2. 55	1630	7. 2	8. 5	20. 0	0. 0	3. 1	4. 9	17. 0	0. 5	0. 0	4. 8	6. 0	14. 7
31/07/80		3. 93	191. 17	0. 523	0. 561	44. 48	2. 55	1620	7. 8	7. 1	17. 6	0. 0	4. 7	4. 8	15. 5	0. 2	0. 0	5. 4	5. 8	14. 0
01/08/80																				
18/08/80		3. 90	189. 27	0. 463	0. 437	34. 30	2. 55	1650	7. 4	6. 8	16. 8	0. 0	5. 0	4. 5	14. 8	1. 1	0. 0	5. 3	5. 8	14. 3
01/09/80																				
22/09/80		4. 09	201. 28	0. 439	0. 525	43. 82	2. 46	1560	7. 6	6. 9	16. 5	0. 0	4. 7	4. 8	15. 0	0. 1	0. 0	4. 5	5. 8	14. 3
01/10/80																				
04/10/80		3. 33	153. 25	0. 539	0. 465	29. 55	2. 18	1440	7. 4	5. 2	13. 0	0. 0	5. 3	4. 8	11. 6	0. 2	0. 0	5. 4	6. 6	9. 9
27/10/80		3. 77	181. 06	0. 403	0. 418	31. 39	2. 09	1380	7. 8	5. 5	14. 2	0. 0	5. 3	3. 8	11. 8	0. 1	0. 0	6. 7	3. 0	11. 3
01/11/80																				
11/11/80		3. 87	187. 38	0. 308	0. 360	27. 98	2. 28	1510	7. 9	5. 0	13. 3	0. 0	5. 4	5. 7	11. 7	0. 2	0. 0	7. 6	3. 4	12. 0
24/11/80		3. 93	191. 17	0. 345		28. 28	2. 73		7. 5				6. 8	2. 3	6. 2	0. 2	0. 0	4. 6		20. 0
01/12/80																				
07/12/80		3. 80	182. 95	0. 312	0. 369	28. 00	2. 73	1780	7. 3	4. 7	11. 9	0. 0	5. 8	9. 2	13. 0	0. 2	0. 0	4. 0	11. 7	12. 5
25/12/80		3. 88	188. 01	0. 398	0. 359	27. 99	2. 18	1490	8. 2	5. 6	13. 4	0. 0	3. 9	5. 6	12. 3	0. 2	0. 0	4. 2	13. 1	4. 7
01/01/81																				
07/01/81		4. 20	208. 23	0. 425	0. 512	44. 21	2. 18	1410	7. 5	4. 3	10. 5	0. 0	1. 8	9. 5	10. 2	0. 3	0. 0	4. 3	10. 2	7. 3

3. 7. EH 13 Calculation sheet after calculation and interpolation of discharges

Observation year : 1980
Catchment area : Bahr Hadus drain
Measurement point : EH 13
Remarks : Data on discharges of 1979, 1981 and 1982 are also used

Waterdepth : D = 2. 86 - Hm
Pendulum constant : c_P = Q = 247 $\bar{v}_p$
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) ^.....

Date	P	D (dH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q** (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
07/12/80					0. 139	34. 33														
08/12/79						35. 47	2. 13	1400	7. 6	5. 7	13. 7	0. 0	4. 4	4. 6	12. 0	0. 2	0. 0	4. 8	7. 9	8. 5
25/12/80					0. 222	54. 83														
01/01/80																				
07/01/80					0. 148	36. 56	2. 24	1430	8. 2	6. 8	15. 5	0. 0	4. 8	3. 6	13. 9	0. 2	0. 0	3. 8	5. 2	13. 5
28/01/80						12. 20	4. 33	2690	7. 6	11. 7	29. 1	0. 0	9. 0	4. 1	30. 0	0. 1	0. 0	4. 9	8. 7	29. 6
01/02/80		2. 19				7. 56														
11/02/80						22. 65	5. 78	3520	7. 4	11. 1	29. 4	0. 0	11. 0	10. 4	36. 2	0. 2	0. 0	5. 3	11. 7	40. 8
23/02/81		2. 29				40. 75														
26/02/80						42. 16	2. 21	1400	7. 3	5. 0	11. 7	0. 0	5. 0	5. 5	11. 4	0. 2	0. 0	3. 6	7. 0	11. 5
01/03/80																				
10/03/80						48. 26	2. 04	1270	7. 3	3. 3	8. 1	0. 0	4. 7	7. 3	8. 2	0. 2	0. 0	3. 6	5. 8	11. 0
24/03/80						51. 56	2. 64	1710	-	6. 1	16. 4	0. 0	6. 3	5. 3	14. 6	0. 2	0. 0	8. 0	2. 7	15. 7
01/04/80																				
10/04/79						55. 57														
14/04/80						55. 34	2. 47	1440	7. 2	5. 6	8. 6	0. 0	5. 0	5. 9	13. 0	0. 2	0. 0	0. 8	6. 8	16. 5
21/04/80						54. 94	2. 13	1380	7. 5	6. 5	15. 1	0. 0	4. 0	4. 1	13. 0	0. 1	0. 0	4. 4	6. 3	10. 5
01/05/80																				
05/05/80						54. 14	2. 29	1490	7. 4	6. 1	12. 6	0. 0	4. 2	5. 3	13. 2	0. 2	0. 0	2. 3	12. 6	8. 0
19/05/79						53. 34														
27/05/80						51. 21	2. 16	1390	7. 6	6. 3	14. 8	0. 0	5. 0	3. 6	13. 0	0. 0	0. 0	4. 4	5. 2	12. 0
01/06/80																				
04/06/80						49. 08	2. 46	1510	7. 6	4. 8	10. 4	0. 0	6. 2	6. 1	12. 0	0. 3	0. 0	2. 2	7. 4	15. 0
16/06/80						45. 89	2. 33	1460	7. 1	6. 2	15. 4	0. 0	5. 0	4. 5	13. 6	0. 2	0. 0	5. 2	1. 7	16. 4
19/06/79						45. 09														
01/07/80						46. 91	2. 73	1660	7. 1	6. 8	16. 9	0. 0	6. 0	4. 5	15. 6	0. 2	0. 0	5. 2	4. 6	16. 5
14/07/79						48. 89														
16/07/80						49. 33	2. 73	1780	7. 3	9. 2	21. 8	0. 0	3. 6	4. 9	19. 0	0. 2	0. 0	4. 8	7. 7	15. 2
01/08/80						52. 84	2. 82	1800	7. 7	6. 9	17. 4	0. 0	6. 3	5. 2	16. 5	0. 2	0. 0	5. 4	6. 9	15. 9
06/08/80		2. 32			0. 218	53. 94														
18/08/80		2. 31			0. 190	46. 93	2. 73	1750	7. 4	6. 6	16. 6	0. 0	5. 2	5. 6	15. 3	1. 1	0. 0	5. 4	6. 2	15. 6
01/09/80																				
22/09/80					0. 187	46. 19	2. 73	1730	7. 5	6. 5	16. 5	0. 0	5. 7	5. 8	15. 7	0. 1	0. 0	5. 2	6. 0	16. 1
01/10/80																				
04/10/80					0. 239	59. 03	2. 46	1620	7. 3	10. 0	23. 6	0. 2	3. 2	2. 8	17. 4	1. 2	0. 0	6. 2	3. 6	14. 8
27/10/80					0. 255	62. 99	2. 18	1420	8. 0	5. 3	13. 8	0. 0	5. 0	5. 0	11. 9	0. 1	0. 0	6. 6	2. 7	12. 7
01/11/80																				
11/11/80					0. 186	45. 94	2. 46	1600	7. 8	5. 8	15. 5	0. 0	5. 1	6. 0	13. 7	0. 2	0. 0	7. 6	2. 1	15. 3
15/11/81		2. 32				46. 17														
24/11/80					0. 176	43. 47	3. 28	2150	7. 4	7. 5	18. 5	0. 0	8. 0	4. 8	18. 9	1. 1	0. 0	4. 5	14. 0	14. 3
01/12/80																				
07/12/80					0. 139	34. 33	3. 19	2020	7. 4	7. 6	19. 0	0. 0	5. 8	6. 2	18. 7	0. 5	0. 0	4. 8	12. 0	14. 4
25/12/80					0. 222	54. 83	2. 55	1780	8. 1	9. 1	21. 7	0. 0	3. 9	3. 7	17. 8	0. 1	0. 0	5. 4	15. 9	4. 2
01/01/81																				
07/01/81					0. 148	36. 56	1. 15	750	7. 1	3. 8	8. 5	0. 0	2. 0	3. 1	6. 1	0. 2	0. 0	4. 5	0. 5	6. 4

ANNEX 4: SEQUENTIAL LIST OF MEASUREMENT POINTS FOR CROSS-CHECKING

4. 1. Fayum area

4. 2. Eastern Delta

4. 3. Middle Delta

4. 4. Western Delta

1. FAYUM AREA

1.1. Batts drain catchment area

FB 01* and FB 02	FB 01 Batts drain at Seyla
FB 02 and FB 03	FB 02 Batts drain at Sireisna
FB 03 and FB 04	
FB 03 + FB 04 and FB 05	FB 03 Batts drain at Furgus
	FB 04 Roda drain
FB 05 and FB 06	FB 05 Batts drain at Tamya
	FB 06 Batts drain at "Outfall"

1.2. Wadi drain catchment area

FW 01 and FW 02	FW 01 Tagan drain
FW 02 and FW 03 + FW 04	FW 02 Tahwila Wadi drain at Nowara
FW 05 and FW 06	FW 05 pump station No. 3
FW 04 and FW 06	FW 06 Abu Owad drain
FW 04 and FW 07 + FW 08	FW 04 Tahwila Wadi drain at Abu Gandir
	FW 08 Wadi Rayan drain at "Outfall"
FW 03 + FW 07 and FW 09	FW 03 Wadi drain at Abu Gandir
	FW 07 Tahwila Wadi drain at "Spillway"
FW 09 and FW 10	FW 09 Wadi drain at Nezzla
	FW 10 Wadi drain at "Outfall"

2. EASTERN DELTA

2.1. Bahr Bagar drain catchment area

EB 01 and EB 02	
EB 01 + EB 02 and EB 03 + EB 04	EB 01 Bilbeis drain
	EB 02 Qalyubeya drain
	EB 03 Wadi pump station
EB 04 and EB 05	EB 04 Bahr Bagar drain at "Railroad bridge"
EB 05 and EB 07	EB 05 Bahr Bagar drain at Fagus
EB 07 and EB 08	EB 07 Bahr Bagar drain at "Kubri Saud"
EB 06 and EB 10	EB 06 Saada pump station
	EB 10 Bahr Bagar pump station
EB 08 and EB 09	EB 09 Bahr Bagar irrigation pump station
EB 08 and EB 11	EB 08 Bahr Bagar drain at 'Kubri Bahr Bagar'
	EB 11 Bahr Bagar drain at "Outfall"

2.2. Bahr Hadus catchment area

EH 01 + EH 02 and EH 03	EH 01 Bahr Saft El Qibly drain
	EH 02 Hanut pump station
EH 03 and EH 05	EH 03 Sadaga pump station
EH 05 and EH 06	EH 05 Nizam pump station
EH 06 and EH 08	
EH 07 and EH 08	EH 07 Additional Qassabi pump station
EH 06 and EH 09	EH 06 Bani Ebeid pump station
	EH 09 Geneena pump station
EH 08 and EH 10	
EH 10 and EH 11	
EH 08 and EH 12	EH 08 Main Qassabi pump station
	EH 12 Saft pump station
EH 11 and EH 13	EH 11 Bahr Hadus drain at "Bahr Hadus Bridge"
	EH 13 Bahr Hadus drain at "Outfall"

* The underlined measurement points are considered fully checked and ready for data presentation

2. 3. Matareya catchment area

EH 10 and EM 01	EH 10 Erad pump station

2. 4. Serua catchment area

EM 01 and ES 01 + ES 02	EM 01 Matareya pump station ES 01 Upper Serua pump station ES 02 Lower Serua pump station

3. MIDDLE DELTA

3. 1. Drain No. 1 catchment area

M1 01 and M1 02	
M1 01 + M1 02 and M1 03	M1 01 upper pump station No. 1 M1 02 drain No. 1 at 'Bridge drain 1'
M1 03 and M1 04	M1 03 lower pump station No. 1 M1 04 pump station No. 2

3. 2. Gharbia drain catchment area

MG 01 and MG 03	MG 01 East Minufeya pump station MG 03 Mahallet Ruh pump station
MG 02 and MG 04	MG 02 Segaaya pump station
MG 04 and MG 05	MG 04 Sematay pump station
MG 05 and MG 07	MG 05 pump station No. 5
MG 06 and MG 07	
MG 06 and MG 08	
MG 07 and MG 09	MG 07 pump station No. 6
MG 09 and MG 10	MG 09 pump station No. 4
MG 06 + MG 08 and MG 11	MG 06 Charbia drain at 'Kubri No. 6' MG 08 Hamul pump station
MG 10 and MG 12	MG 10 pump station No. 3
MG 11 and MG 13	MG 11 Gharbia drain at 'Kubri No. 7' MG 13 Gharbia drain at 'Outfall'

3. 3. Tira catchment area

MG 12 and MT 01	MG 12 Hafir Shehab Eddin pump station

3. 4. Drain No. 7 catchment area

MT 01 and M7 01	MT 01 Tira pump station

3. 5. Drain No. 8 catchment area

M7 01 and M8 01	M7 01 pump station No. 7 M8 01 lower pump station No. 8

3. 6. Nashart drain catchment area

MN 01 and MN 02	
MN 02 and MN 04	
MN 01 + MN 02 and MN 03	MN 01 upper pump station No. 8 MN 02 Mandura pump station MN 03 Nashart drain at 'Bridge'

3. 7. Drain No. 11 catchment area

MN 04 and M1 11	MN 04 Zeini pump station M1 11 pump station No. 11

3. 8. Tilla and Sabal drain catchment area

MK 01 and MS 01	MK 01 Tilla drain outfall
	MS 01 Sabal drain outfall

4. WESTERN DELTA

4. 1. Edko drain catchment area

WE 01 and WE 06	WE 01 Etay Barud pump station
WE 05 and WE 06	WE 05 Dilingat pump station
	WE 06 Khandak El Gharbi pump station
WE 02 and WE 03	
WE 02 and WE 07	WE 07 Khairy pump station
WE 02 and WE 04	WE 02 Shubrakhit pump station
	WE 04 Edko irrigation pump station
WE 03 and WE 08	WE 03 Zargun pump station
WE 08 and WE 10	
WE 08 and WE 09	
WE 10 and WE 11	WE 10 Edko pump station
	WE 11 Bosseili pump station
WE 09 and WE 12	WE 09 Edko drain at 'Kubri Edko'
	WE 12 Edko drain at 'Outfall'

4. 2. Barsik catchment area

WE 08 and WB 01	WE 08 Halq El Gamal pump station

4. 3. Tabia catchment area

WB 01 and WT 01	WB 01 Barsik pump station
	WT 01 Tabia pump station

4. 4. Umum drain catchment area

WU 01 and WU 02	WU 01 Umum drain at 'Kubri Shireishra'
WU 02 and WU 03	WU 02 Shireishra pump station
WU 03 and WU 04	
WU 03 and WU 05	WU 03 Truga pump station
WU 05 and WU 06	
WU 06 and WU 07	WU 06 Hares pump station
WU 07 and WU 08	WU 07 Mariut pump station
	WU 08 Qalaa pump station
WU 05 and WU 09	WU 05 Dushudi pump station
	WU 09 Max pump station

ANNEX 5: DATA SHEETS WITH PRELIMINARY CORRECTIONS

5.1. FB 03, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Batts drain
Measurement point : FB 03
Remarks :

Waterdepth : D = 3.88 - Hm
Pendulum constant : c_p = 0.630
Float constant : c_D = 0.879 + ... D
Calibration : Q = ... (D .....)

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79		1.40	11.06	0.273	-	3.39*	1.18	800	8.0	3.3	7.8	0.0	3.1	2.7	5.6	0.3	0.0	5.5	0.6	5.6
01/01/80																				
09/01/80		1.58	12.86	0.336	-	3.80	1.45*	940	8.3	2.7	6.4	0.0	3.6	5.3	5.6	0.1	0.0	4.2	3.4	7.0
23/01/80		0.51	3.08	0.198	-	0.54	4.83		7.4				6.6	10.1	35.0	0.7	0.0	5.3	17.0	30.1
01/02/80																				
06/02/80		0.46	2.78	0.233	-	0.57	4.17*	3140	7.4	8.8	25.3	0.0	8.5	11.7	28.0	0.7	0.0	8.8	16.1	24.0
24/02/80		1.69	13.96	0.346	-	4.25	1.09*	640	7.6	3.7	7.5	0.0	2.6	1.	5.2	0.4	0.0	3.5	0.8	5.3
01/03/80																				
14/03/80		1.16	8.66	0.367	-	2.79	1.43	950	7.8	3.3	8.1	0.0	4.5	3.1	6.5	0.1	0.0	5.2	2.8	6.2
01/04/80																				
04/04/80		1.08	7.86	0.470	1.353	2.55*	1.28	870	7.5	4.5	9.6	0.0	4.0	1.2	7.3	0.3	0.0	3.5	3.9	5.4
18/04/80		1.08	7.86	0.409	0.622	2.71*	1.45	990	7.4	4.9	10.9	0.0	3.0	3.2	8.6	0.2	0.0	4.0	4.0	7.0
30/04/80		1.11	8.16	0.452	0.698	2.58*	1.22	810	7.6	4.4	9.6	0.0	2.6	2.4	7.0	0.2	0.0	4.0	2.2	6.0
01/05/80																				
18/05/80		1.03	7.36	0.451	0.762	2.40*	1.51	1000	8.0	5.3	11.7	0.0	3.0	2.7	9.0	0.3	0.0	4.0	4.4	6.6
01/06/80																				
02/06/80		0.85	5.56	0.380	-	1.56*	1.24	840	7.8	4.3	9.8	0.0	3.8	1.4	7.0	0.2	0.0	4.8	1.0	6.6
28/06/80		0.94	6.46	0.428	0.597	1.71	1.33	900	7.3	3.8	8.7	0.0	4.5	1.8	6.7	0.3	0.0	4.4	3.3	5.6
01/07/80																				
11/07/80		0.86	5.66	0.383	0.579	1.82	1.78*	1260	7.7	7.9	17.1	0.0	3.6	1.8	13.0	0.2	0.0	4.1	7.6	6.9
25/07/80		1.02	7.26	0.345	0.540	2.17	1.35		7.5				3.2	2.4	7.8	0.2	0.0	2.1	5.8	5.7
01/08/80																				
01/09/80																				
17/09/80		1.38	10.86	0.313	0.568	3.42	1.31	910	7.6	4.9	11.3	0.8	3.2	1.8	7.7	0.4	0.0	5.8	1.2	6.1
01/10/80																				
11/10/80		1.22	9.26	0.291	0.478	3.15*	1.66	1130	7.9	5.0	12.5	0.0	3.7	3.3	9.3	0.2	0.0	7.0	2.1	7.4
01/11/80																				
04/11/80		0.91	6.16	0.338	0.528	1.80	1.68	1180	7.9	5.3	13.4	0.0	3.7	3.3	10.0	0.2	0.0	7.0	2.8	7.4
09/11/80		1.12	8.26	0.308	0.475	2.17	1.58	1070	7.8	4.8	11.7	0.0	3.9	2.8	8.7	0.2	0.0	6.4	3.0	6.2
01/12/80																				
17/12/80		1.21	9.16	0.353	0.598	3.03	2.00	1380	7.3	5.9	13.0	0.0	4.2	3.8	11.7	0.4	0.0	3.4	6.8*	9.9*
01/01/81																				
17/01/81		1.16	8.66	0.375	0.624	2.99	2.37	1490	7.3	5.4	13.3	0.0	4.6	6.3	12.5	0.2	0.0	4.8	5.0	13.8

* preliminary corrected data

5.2. FB 04, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Batts drain
Measurement point : FB 04
Remarks :

Waterdepth : D = 4.04 - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....)

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
17/12/80*		0.93	6.01	0.668		4.01	2.18	1530	7.2	8.3	18.2	0.0	3.2	3.4	15.0	0.4	0.0	4.0	14.3	3.7
01/01/80																				
09/01/80		0.55	3.35	0.865		4.31*	2.47	1590	8.4	5.4	13.5	0.0	5.4	6.1	13.0	0.2	0.0	4.7	8.7	11.3
23/01/80		0.01	0.45	0.264		0.12	8.42	5980	7.4	16.8	49.3	0.0	6.8	23.1	65.0	0.7	0.0	9.3	33.2	53.1
01/02/80																				
06/02/80		-0.02	0.33	0.454		0.15	8.25	6160	7.6	18.2	49.6	0.0	14.8	13.4	68.5	0.6	0.0	5.8	40.1	51.4
24/02/80		0.67	4.19	1.143		4.79	1.87	1250	7.6	4.9	11.7	0.0	5.2	3.3	10.2	0.4	0.0	4.4	5.6	9.1
01/03/80																				
14/03/80		0.44	2.65	1.159		3.07	2.13	14.00	7.9	3.7	10.1	0.0	5.0	6.9	12.7*	0.2	0.0	7.2	8.5*	9.1
01/04/80																				
04/04/80		0.44	2.65	1.014		2.69	1.87	1240	7.5	4.9	11.6	0.0	5.0	3.2	10.0	0.4	0.0	4.2	7.2*	7.2*
18/04/80		0.50	3.01	0.901		2.71	1.42	930	7.4	4.9	10.8	0.0	3.0	2.7	8.3	0.2	0.0	4.0	4.2*	6.0*
30/04/80		0.51	3.07	0.901		2.77	1.44	970	7.6	6.5	13.7	0.0	2.6	1.9	9.8	0.2	0.0	4.0	3.3	7.2
01/05/80																				
18/05/80		0.45	2.71	0.911		2.47	1.48	970	7.9	5.2	12.0	0.0	3.0	2.7	8.8	0.2	0.0	5.2	3.2*	6.3*
01/06/80																				
02/06/80		0.15	1.15	0.807		0.93	2.38	1570	7.9	7.0	17.2	0.0	5.4	3.4	14.6	0.3	0.0	5.6	7.5	10.6
28/06/80		0.20	1.40	0.675		0.95	2.72	1770	7.4	8.2	19.8	0.0	4.7	4.5	17.6	0.4	0.0	5.0	9.0	13.2
01/07/80																				
11/07/80		0.22	1.50	1.112		1.16*	2.81	1820	7.4	10.5	23.9	0.0	4.2	3.0	20.0	0.4	0.0	4.5	10.2	12.9
25/07/80		0.35	2.15	0.777		1.67	2.73+		7.4				4.7	4.3	16.2	0.2	0.0	4.4	8.5	12.5
01/08/80																				
01/09/80																				
17/09/80		0.95	6.15	0.587		3.61	2.28	1520	7.7	8.2	19.0	0.0	4.2	2.8	15.4	0.4	0.0	4.8	8.3	9.7
01/10/80																				
11/10/80		0.90	5.80	0.686		3.98	2.18	1490	8.0	6.2	15.8	0.0	5.8	3.0	13.0	0.2	0.0	6.7	6.2	9.1
01/11/80																				
04/11/80		0.76	4.82	0.691		2.17*	2.22	1520	8.0	6.4	16.4	0.0	5.8	3.0	13.5	0.2	0.0	6.7	6.7	9.1
09/11/80		0.75	4.75	0.742		3.52	2.27	1530	7.9	6.3	15.9	0.0	5.5	3.5	13.3	0.4	0.0	6.4	7.2	9.1
01/12/80																				
17/12/80		0.93	6.01	0.668		4.01	2.18	1530	7.2	8.3	18.2	0.0	3.2	3.4	15.0	0.4	0.0	4.0	7.9*	10.1*
01/01/81																				
17/01/81		0.88	5.66	0.661		3.74	3.35*		7.2				5.9	3.6	22.0	0.4	0.0	4.8	8.5	18.6

* preliminary corrected data

5. 3. FB 05, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Batta drain
Measurement point : FB 05
Remarks :

Waterdepth : D = 4.72 - Hm
Pendulum constant : c_p = ...
Float constant : c_D = 1.559 . - 0.472 D
Calibration : Q = ... (D .....)

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79		1.24	7.61	1.207		8.95	1.31	890	8.0	3.1	7.5	0.0	4.0	3.2	5.8	0.2	0.0	5.5	1.6	6.1
01/01/80																				
09/01/80		1.17	7.13	1.262		9.06	1.87	1240	8.6	5.4	12.9	0.0	4.2	3.6	10.6	0.3	0.0	5.1	5.1	8.5
23/01/80		0.33	1.52	0.618		1.32	5.70	3460	7.8	11.0	27.9	0.0	6.6	13.7	35.0	0.6	0.0	4.2	19.7	32.0
01/02/80																				
06/02/80		0.22	0.97	0.863		1.22	11.82	8250	7.7	29.7	82.5	0.0	12.7	10.0	100.0	0.3	0.0	8.6	36.4*	78.0**
24/02/80		1.31	8.09	1.332		10.14	0.95	660	7.1	3.8	7.0	0.0	3.7	0.4	5.5	0.3	0.0	2.3	3.6*	4.0*
01/03/80																				
14/03/80		0.93	5.47	1.215		7.45	1.96	1300	7.4	4.4	11.7	0.0	4.0	5.5	9.6	0.3	0.0	6.0	2.3	9.1
01/04/80																				
04/04/80		1.00	5.95	1.720		7.15*	1.02	730	7.6	3.9	8.4	0.1	3.5	0.8	5.7	0.3	0.0	4.4	2.1	3.8
18/04/80		1.02	6.09	1.308		8.59*	1.45	960	7.4	5.1	11.2	0.0	3.5	2.2	8.6	0.2	0.0	4.0	3.0	7.5
30/04/80		1.06	6.37	1.359		7.46	1.29	860	7.3	4.4	9.7	0.0	2.9	2.6	7.3	0.2	0.0	4.0	2.4	6.6
01/05/80																				
18/05/80		0.83	4.78	1.344		6.21*	1.34	860	7.9	3.5	8.0	0.0	3.5	3.2	6.4	0.2	0.0	4.0	3.3*	6.0*
01/06/80																				
02/06/80		0.59	3.12	1.286		4.05*	1.59	1040	8.0	3.2	7.8	0.0	4.9	3.9	8.9*	0.2	0.0	4.4	6.5*	7.0
28/06/80		0.70	3.88	1.080		5.15	2.04	1360	7.4	6.2	14.9	0.0	4.2	3.6	12.3	0.4	0.0	5.0	6.1	9.4
01/07/80																				
11/07/80		0.70	3.88	1.130		5.39	2.29	1530	7.6	11.3	23.2	0.0	3.1	1.8	17.7	0.3	0.0	3.8	9.4	9.7
25/07/80		0.92	5.40	1.055		6.41	1.80*		7.8				2.6	2.4	11.0	0.1	0.0	4.8	2.5	8.8
01/08/80																				
01/09/80																				
17/09/80		1.32	8.16	1.098		8.39	1.91	1280	7.8	7.4	16.8	0.0	3.7	2.3	12.8	0.2	0.0	4.8	6.0	8.2
01/10/80																				
11/10/80		1.24	7.61	1.122		8.32	1.91	1350	7.7	5.5	14.0	0.0	3.7	4.8	11.3	0.2	0.0	6.7	5.6	7.7
01/11/80																				
04/11/80		1.01*	6.57	0.953		6.21*	1.94	1400	7.7	5.8	14.8	0.0	3.7	4.8	12.0	0.2	0.0	6.7	6.3	7.7
09/11/80		1.11	6.71	0.993		6.90	2.00	1380	8.4	6.3	15.8	0.0	4.5	3.0	12.2	0.4	0.0	7.0	4.9	8.2
01/12/80																				
17/12/80		1.30	8.02	1.029		9.26*	2.00	1400	7.4	6.8	15.5	0.0	3.7	3.3	12.7	0.4	0.0	4.4	6.1*	9.6*
01/01/81																				
17/01/81		1.32	8.16	1.029		9.29*	2.46	1560	7.2	7.9	18.8	0.0	3.6	4.6	16.0	0.4	0.0	5.0	7.4*	12.2*

* preliminary corrected data

5. 4. EB 07, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Bahr baqar drain
Measurement point : EB 07
Remarks :

Waterdepth : D = 5.02 - Hm
Pendulum constant : c_p = ...
Float constant : c_D = - 1.23 + 0.667 D
Calibration : Q = ... (D .....)

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79		3.27	104.97	0.424		42.26	1.02	730	7.1	3.2	7.3	0.3	4.4	0.6	5.0	0.2	0.0	5.3	0.8	4.1
01/01/80																				
06/01/80		3.04	93.52	0.387		28.32	1.18	820	7.2	3.1	7.3	0.0	3.6	2.4	5.4	0.3	0.0	5.1	2.8	3.8
27/01/80		2.92	87.54	0.453		28.40	1.46	1010	7.6	3.0	7.6	0.0	4.6	3.8	6.1	0.1	0.0	7.7	0.8	6.1
01/02/80																				
10/02/80		2.74	79.04	0.382		18.00	1.45	970	7.6	2.9	7.4	0.0	4.7	3.3	5.7	0.2	0.0	7.4	1.2	5.3
25/02/80		3.05	94.01	0.448	0.607	33.81	1.79	1180	7.2	7.1	16.1	0.0	3.7	2.0	12.0	0.2	0.0	4.9	3.4	9.6
01/03/80																				
09/03/80		2.96	89.53	0.460	0.562	30.59	1.17	780	7.7	0.5	1.4	0.0	5.2	5.2	1.2	0.2	0.0	5.2	2.3	4.3
23/03/80		2.91	87.04	0.313	0.554	26.27*	1.28*	1080	-	3.7	9.9	3.5	3.7	3.6	7.0	0.2	0.0	10.8	0.1	3.6
01/04/80																				
13/04/80		2.84	83.66	0.447	0.522	24.79	1.16	770	7.5	2.8	4.7	0.0	3.5	3.1	5.1	0.3	0.0	1.2	5.8	5.0
20/04/80		2.81	82.22	0.532	0.827	22.22*	1.12	800	7.3	3.3	7.9	0.7	3.0	2.7	5.5	0.1	0.0	6.4	0.9	4.0
01/05/80																				
04/05/80		2.81	82.22	0.397	0.543	20.98	1.22	820	7.2	3.9	8.3	0.0	3.2	2.4	6.6	0.1	0.0	3.2	4.1	5.0
26/05/80		2.88	85.57	0.313	0.539	23.13*	1.00	700	7.4	1.7	4.1	0.0	3.2	3.4	3.0	0.4	0.0	5.6	1.0	3.4
01/06/80																				
03/06/80		2.90	86.54	0.388	0.537	23.60	1.07	760	7.0	2.5	6.2	1.1	2.6	3.5	4.3	0.2	0.0	7.2	0.0	3.5
15/06/80		2.86	84.61	0.465	0.725	26.60	1.04	710	7.4	2.3	5.5	0.0	4.4	1.7	4.0	0.2	0.0	5.2	2.4*	2.7*
29/06/80		2.88	85.57	0.464	0.684	27.38	1.13	710	7.4	2.3	5.5	0.0	4.4	1.7	4.0	0.2	0.0	5.2	0.4	4.7
01/07/80																				
16/07/80		2.95	89.03	0.402	0.661	26.35	1.36*	820	7.3	5.7	11.7	0.1	2.2	1.8	8.0	0.2	0.0	4.1	1.8	6.3
31/07/80		3.08	95.51	0.403	0.715	31.67	1.04	720	8.1	2.7	6.3	0.0	3.4	2.3	4.5	0.2	0.0	5.4	0.8	4.2
01/08/80																				
18/08/80		-	-	-	-	28.52**	1.02	720	8.6	2.3	5.5	0.0	3.2	2.9	4.0	0.2	0.0	5.4	1.4	3.6
01/09/80																				
22/09/80		3.22	102.48	0.357	0.551	33.52	1.06	750	7.4	3.0	7.0	0.0	3.2	2.4	5.0	0.2	0.0	5.4	1.3	4.1
01/10/80																				
04/10/80		3.18	100.49	0.396	0.599	35.40	1.13	830	7.3	2.4	6.0	0.4	3.7	2.3	4.2	1.2	0.0	6.4	1.4	3.6
27/10/80		3.09	96.01	0.302	0.536	24.05	1.15	760	7.3	1.6	3.9	0.0	4.2	3.3	3.1	0.6	0.0	5.0	0.9	5.3
01/11/80																				
11/11/80		3.04	93.52	0.471	0.726	35.07	1.16	860	7.8	2.4	6.2	0.0	4.6	2.7	4.6	0.2	0.0	7.0	0.8	4.3
24/11/80		3.10	96.50	0.325	0.522	26.23	1.66	1190	7.4	3.5	8.9	0.0	4.6	3.1	6.9	2.0	0.0	6.4	6.0	4.2
01/12/80																				
07/12/80		3.07	95.01	0.318	0.411	24.66	1.47	1040	7.3	2.1	5.6	0.0	5.2	4.8	4.7	0.2	0.0	7.0	0.2*	7.7*
25/12/80		3.32	107.46	0.373	0.449	39.40	1.40	970	7.9	4.4	10.5	0.0	3.2	3.0	7.7	0.1	0.0	5.8	3.7	4.5
01/01/81																				
07/01/81		3.03	93.03	-	0.486	24.02	1.27*	1030	7.0	3.2	8.1	0.0	2.5	4.8	6.1	1.2	0.0	6.6	4.2	3.8

* preliminary corrected data ** estimated (missing) data

5. 5. EB 08, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Bahr Baqar drain
Measurement point : EB 08
Remarks :

Waterdepth : D = 5. 27 - Hm
Pendulum constant : c_p = 0. 715
Float constant : c_D = - 0. 93 + 0. 598 D
Calibration : Q = _____ (D _____) _____

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79		3. 16	110. 48	0. 387		41. 11	1. 04	730	7. 2	2. 4	5. 8	0. 0	5. 0	1. 0	4. 2	0. 2	0. 0	5. 5	0. 3	4. 6
01/01/80																				
06/01/80		2. 96	101. 12	0. 369		28. 11*	1. 16	790	7. 1	2. 5	6. 2	0. 1	3. 9	2. 6	4. 5	0. 2	0. 0	6. 6	0. 0	4. 6
27/01/80		2. 85	95. 97	0. 363		27. 03	2. 21+		7. 6				8. 7	8. 1	5. 0	0. 2	0. 0	7. 3	9. 1	5. 6
01/02/80																				
10/02/80		2. 73	90. 46	0. 349		22. 23	1. 70	1200	7. 6	3. 6	9. 6	0. 0	5. 2	4. 2	7. 9	0. 2	0. 0	7. 4	3. 4	6. 7
25/02/80		2. 94	100. 19	-		-	1. 02	710	7. 0	2. 0	4. 7	0. 0	3. 7	2. 7	3. 5	0. 2	0. 0	5. 2	2. 0	2. 9
01/03/80																				
09/03/80		2. 87	96. 91	0. 356	0. 448	24. 46	1. 14	780	7. 2	1. 3	3. 3	0. 0	4. 7	3. 8	2. 7	0. 2	0. 0	5. 2	2. 4	3. 8
23/03/80		2. 93	99. 72	0. 190	0. 443	26. 02	1. 37*	1230	-	4. 4	11. 9	3. 1	5. 2	2. 5	8. 6	0. 2	0. 0	10. 8	2. 1	3. 6
01/04/80																				
13/04/80		2. 82	94. 57	0. 357	0. 410	21. 02	1. 22	780	7. 2	2. 8	4. 8	0. 0	4. 0	3. 1	5. 3	0. 3	0. 0	1. 2	6. 8*	4. 7*
20/04/80		2. 69	88. 49	0. 503	0. 505	21. 74	1. 16	800	7. 3	2. 6	6. 5	0. 0	3. 0	3. 6	4. 8	0. 1	0. 0	6. 0	1. 5	4. 0
01/05/80																				
04/05/80		2. 45	77. 37	0. 281	0. 466	13. 84	1. 21	790	7. 2	2. 3	5. 2	0. 0	3. 7	3. 8	4. 5	0. 1	0. 0	3. 2	3. 9	5. 0
26/05/80		2. 81	94. 10	0. 215	0. 428	21. 66	1. 04	720	7. 4	2. 1	5. 1	0. 0	3. 5	2. 7	3. 7	0. 4	0. 0	5. 6	0. 6	4. 1
01/06/80																				
03/06/80		2. 83	95. 04	0. 228	0. 423	21. 96	1. 10	760	7. 3	2. 3	5. 7	0. 0	3. 6	3. 0	4. 2	0. 2	0. 0	6. 0	0. 6	4. 4
15/06/80		2. 77	92. 23	0. 366	0. 505	24. 25	1. 11	770	7. 3	3. 1	7. 3	0. 0	3. 6	2. 1	5. 2	0. 2	0. 0	5. 4	1. 0	4. 7
29/06/80		2. 72	89. 89	0. 312	0. 483	21. 68	1. 11	770	7. 3	3. 1	7. 4	0. 0	3. 6	2. 1	5. 3	0. 1	0. 0	5. 4	1. 0	4. 7
01/07/80																				
16/07/80		2. 74	90. 83	0. 394	0. 530	24. 45	1. 29*	850	7. 5	5. 4	12. 4	2. 5	3. 2	0. 8	7. 7	0. 2	0. 0	6. 5	0. 3	5. 1
31/07/80		2. 83	95. 04	0. 445	0. 581	30. 17	1. 09	760	7. 8	2. 6	6. 2	0. 0	3. 9	2. 3	4. 5	0. 2	0. 0	6. 0	0. 5	4. 4
01/08/80																				
18/08/80		2. 88	97. 38	0. 405	0. 492	27. 20	1. 13	820	7. 1	2. 5	5. 9	0. 1	3. 2	2. 1	4. 1	2. 0	0. 0	5. 4	1. 1	4. 9
01/09/80																				
22/09/80		3. 09	107. 21	0. 318	0. 543	32. 79*	1. 11	780	7. 6	2. 8	6. 8	0. 0	3. 2	2. 8	4. 9	0. 2	0. 0	5. 8	1. 2	4. 1
01/10/80																				
04/10/80		3. 05	105. 33	0. 348	0. 617	32. 58*	1. 15	810	7. 3	2. 0	5. 0	0. 0	4. 2	3. 3	3. 8	0. 2	0. 0	6. 8	0. 7	4. 0
27/10/80		2. 71	89. 42	0. 224	0. 355	21. 74*	1. 15	810	7. 4	2. 8	7. 0	0. 0	3. 7	2. 8	5. 1	0. 1	0. 0	6. 1	0. 5	5. 1
01/11/80																				
11/11/80		2. 92*	146. 05	0. 407	0. 436	27. 17*	1. 18	830	7. 3	1. 5	4. 1	0. 0	4. 0	4. 6	3. 2	0. 2	0. 0	7. 0	0. 7	4. 3
24/11/80		2. 97	101. 59	0. 305	0. 439	27. 04	1. 67	1210	7. 5	2. 9	7. 5	0. 0	5. 4	3. 2	6. 1	2. 2	0. 0	6. 2	6. 1	4. 6
01/12/80																				
07/12/80		2. 92	99. 25	0. 291	0. 370	25. 67*	1. 61	1150	7. 1	3. 4	8. 7	0. 0	4. 5	4. 8	7. 3	0. 1	0. 0	6. 0	6. 4	4. 3
25/12/80		3. 05	105. 33	0. 392	0. 442	29. 82	1. 32*	1100	8. 0	4. 8	11. 6	0. 0	3. 4	3. 3	8. 7	0. 1	0. 0	6. 0	6. 7	2. 8
01/01/81																				
10/01/81		3. 03	104. 40	0. 340	0. 432	28. 50	1. 44	1010	7. 2	4. 3	10. 4	0. 0	1. 8	4. 7	7. 7	0. 2	0. 0	6. 2	0. 4*	7. 8*

* preliminary corrected data

5. 6. EH 11, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Bahr Hadus drain
Measurement point : EH 11
Remarks :

Waterdepth : D = 6. 23 - Hm
Pendulum constant : c_p = 0. 949
Float constant : c_D = 0. 437 + _____ D
Calibration : Q = _____ (D _____) _____

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79		3. 86	186. 75	0. 511	-	41. 70	1. 57	970	7. 4	3. 9	8. 9	0. 0	5. 5	2. 2	7. 7	0. 2	0. 0	3. 6	6. 2*	5. 8*
01/01/80																				
06/01/80		3. 71	177. 27	0. 376	-	29. 13	2. 52	1550	7. 4	5. 8	14. 0	0. 0	4. 2	7. 0	13. 7	0. 2	0. 0	4. 2	4. 9	16. 0
27/01/80		3. 46	161. 47	0. 298	-	21. 03	3. 83	2390	7. 5	6. 9	18. 3	0. 0	9. 5	8. 6	20. 9	0. 2	0. 0	5. 1	6. 8	27. 3
01/02/80																				
10/02/80		3. 47	162. 10	0. 218	-	15. 44	4. 51	2740	7. 6	8. 0	21. 7	0. 0	8. 9	10. 8	25. 0	0. 2	0. 0	6. 2	7. 5	31. 2
25/02/80		3. 85	186. 11	0. 635	0. 670	32. 43*	0. 99	670	7. 2	1. 9	4. 3	0. 0	3. 8	2. 5	3. 4	0. 2	0. 0	3. 8	3. 8*	2. 3*
01/03/80																				
09/03/80		3. 75	179. 79	0. 450	0. 522	38. 92	1. 87	1180	7. 7	2. 7	6. 4	0. 0	5. 2	6. 8	9. 0*	0. 2	0. 0	3. 6	9. 1*	8. 5
23/03/80		3. 57	168. 42	0. 430	0. 422	29. 47	2. 31	1470	-	4. 7	12. 7	0. 0	5. 2	6. 4	11. 2	0. 2	0. 0	8. 0	0. 2	14. 8
01/04/80																				
13/04/80		3. 72	177. 90	0. 514	0. 476	35. 12	2. 21	1510	7. 4	6. 0	16. 1	0. 0	5. 0	4. 5	13. 0	0. 3	0. 0	9. 2	6. 3	13. 5
20/04/80		3. 71	177. 27	0. 476	0. 470	34. 55	2. 30	1430	7. 7	6. 1	14. 6	0. 0	4. 5	4. 5	13. 0	0. 2	0. 0	4. 4	6. 3	11. 5
01/05/80																				
04/05/80		3. 60	170. 31	0. 307	0. 426	30. 09	2. 50	1550	7. 4	6. 6	13. 9	0. 0	4. 7	5. 3	14. 8	0. 2	0. 0	2. 3	8. 2	14. 5
26/05/80		3. 70	176. 63	0. 423	0. 542	39. 70	1. 60	1030	7. 6	4. 3	10. 0	0. 0	5. 0	2. 6	8. 3	0. 1	0. 0	4. 4	5. 6*	6. 0*
01/06/80																				
03/06/80		3. 62	171. 58	0. 376	0. 347	24. 69	2. 22	1500	7. 3	4. 6	12. 6	0. 0	3. 6	8. 0	11. 0	0. 2	0. 0	8. 8	2. 8	11. 2
15/06/80		3. 74	179. 16	0. 518	0. 576	32. 50*	2. 38	1520	7. 4	7. 1	17. 4	0. 0	4. 4	4. 4	14. 8	0. 2	0. 0	5. 6	3. 2	15. 0
29/06/80		3. 56	167. 79	0. 289	0. 270	29. 86*	2. 55*		7. 4				3. 4	3. 4	15. 7	0. 4	0. 0	5. 6	2. 3	15. 0
01/07/80																				
16/07/80		3. 88	188. 01	0. 540	0. 523	40. 78	2. 55	1630	7. 2	8. 5	20. 0	0. 0	3. 1	4. 9	17. 0	0. 5	0. 0	4. 8	6. 0	14. 7
31/07/80		3. 93	191. 17	0. 523	0. 561	44. 48	2. 55	1620	7. 8	7. 1	17. 6	0. 0	4. 7	4. 8	15. 5	0. 2	0. 0	5. 4	5. 8	14. 0
01/08/80																				
18/08/80		3. 90	189. 27	0. 463	0. 437	34. 30	2. 55	1650	7. 4	6. 8	16. 8	0. 0	5. 0	4. 5	14. 8	1. 1	0. 0	5. 3	5. 8	14. 3
01/09/80																				
22/09/80		4. 09	201. 28	0. 439	0. 525	43. 82	2. 46	1560	7. 6	6. 9	16. 5	0. 0	4. 7	4. 8	15. 0	0. 1	0. 0	4. 5	5. 8	14. 3
01/10/80																				
04/10/80		3. 33	153. 25	0. 539	0. 465	29. 55	2. 18	1440	7. 4	5. 2	13. 0	0. 0	5. 3	4. 8	11. 6	0. 2	0. 0	5. 4	6. 6	9. 9
27/10/80		3. 77	181. 06	0. 403	0. 418	31. 39	2. 09	1380	7. 8	5. 5	14. 2	0. 0	5. 3	3. 8	11. 8	0. 1	0. 0	6. 7	3. 0	11. 3
01/11/80																				
11/11/80		3. 87	187. 38	0. 308	0. 360	35. 37*	2. 28	1510	7. 9	5. 0	13. 3	0. 0	5. 4	5. 7	11. 7	0. 2	0. 0	7. 6	3. 4	12. 0
24/11/80		3. 93	191. 17	0. 345	-	28. 28	2. 73		7. 5				6. 8	2. 3	15. 7*	0. 2	0. 0	4. 6	0. 4*	20. 0
01/12/80																				
07/12/80		3. 80	182. 95	0. 312	0. 369	28. 00	2. 73	1780	7. 3	4. 7	11. 9	0. 0	5. 8	9. 2	13. 0	0. 2	0. 0	4. 0	11. 7	12. 5
25/12/80		3. 88	186. 01	0. 398	0. 359	42. 10*	2. 18	1490	8. 2	5. 6	13. 4	0. 0	3. 9	5. 6	12. 3	0. 2	0. 0	4. 2	6. 9*	10. 9*
01/01/81																				
07/01/81		4. 20	208. 23	0. 425	0. 512	44. 21	2. 18	1410	7. 5	4. 3	10. 5	0. 0	1. 8.	9. 5	10. 2	0. 3	0. 0	4. 3	10. 2	7. 3

* preliminary corrected data

5. 7. EH 13, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Bahr Hadus drain
Measurement point : EH 13
Remarks : Data on discharges of 1979, 1981 and 1982 are also used

Waterdepth : D = 2.86 - Hm
Pendulum constant : c_p = Q = 2.47 $\bar{v}_p$
Float constant : c_D = _____ + _____ D
Calibration : Q = _____ (D _____) _____

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q** (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
07/12/80					0.139	34.33														
08/12/79						35.47	2.13	1400	7.6	5.7	13.7	0.0	4.4	4.6	12.0	0.2	0.0	4.8	7.9	8.5
25/12/80					0.222	54.83														
01/01/80																				
07/01/80					0.148	36.56	2.24	1430	8.2	6.8	15.5	0.0	4.8	3.6	13.9	0.2	0.0	3.8	5.2	13.5
28/01/80						12.20	4.33	2690	7.6	11.7	29.1	0.0	9.0	4.1	30.0	0.1	0.0	4.9	8.7	29.6
01/02/80		2.19				7.56														
11/02/80						22.65	5.78	3520	7.4	11.1	29.4	0.0	11.0	10.4	36.2	0.2	0.0	5.3	11.7	40.8
23/02/81		2.29				40.75														
26/02/80						42.16	2.21	1400	7.3	5.0	11.7	0.0	5.0	5.5	11.4	0.2	0.0	3.6	7.0	11.5
01/03/80																				
10/03/80						48.26	2.04	1270	7.3	3.3	8.1	0.0	4.7	7.3	8.2	0.2	0.0	3.6	5.8	11.0
24/03/80						51.56	2.64	1710	-	6.1	16.4	0.0	6.3	5.3	14.6	0.2	0.0	8.0	2.7	15.7
01/04/80																				
10/04/79						55.57														
14/04/80						55.34	2.47	1440	7.2	5.6	8.6	0.0	5.0	5.9	13.0	0.2	0.0	0.8	6.8	16.5
21/04/80						54.94	2.13	1380	7.5	6.5	15.1	0.0	4.0	4.1	13.0	0.1	0.0	4.4	6.3	10.5
01/05/80																				
05/05/80						54.14	2.29	1490	7.4	6.1	12.6	0.0	4.2	5.3	13.2	0.2	0.0	2.3	8.4*	12.2*
19/05/79						53.34														
27/05/80						51.21	2.16	1390	7.6	6.3	14.8	0.0	5.0	3.6	13.0	0.0	0.0	4.4	5.2	12.0
01/06/80																				
04/06/80						49.08	2.46	1510	7.6	4.8	10.4	0.0	6.2	6.1	12.0	0.3	0.0	2.2	7.4	15.0
16/06/80						45.89	2.33	1460	7.1	6.2	15.4	0.0	5.0	4.5	13.6	0.2	0.0	5.2	5.6*	12.5*
19/06/79						45.09														
01/07/80						46.91	2.73	1660	7.1	6.8	16.9	0.0	6.0	4.5	15.6	0.2	0.0	5.2	4.6	16.5
14/07/79						48.89														
16/07/80						49.33	2.73	1780	7.3	9.2	21.8	0.0	3.6	4.9	19.0	0.2	0.0	4.8	7.7	15.2
01/08/80						52.84	2.82	1800	7.7	6.9	17.4	0.0	6.3	5.2	16.5	0.2	0.0	5.4	6.9	15.9
06/08/80		2.32			0.218	53.94														
18/08/80		2.31			0.190	46.93	2.73	1750	7.4	6.6	16.6	0.0	5.2	5.6	15.3	1.1	0.0	5.4	6.2	15.6
01/09/80																				
22/09/80					0.187	46.19	2.73	1730	7.5	6.5	16.5	0.0	5.7	5.8	15.7	0.1	0.0	5.2	6.0	16.1
01/10/80																				
04/10/80					0.239	59.03	2.46	1620	7.3	10.0	23.6	0.2	3.2	2.8	17.4	1.2	0.0	6.2	3.6	14.8
27/10/80					0.255	62.99	2.18	1420	8.0	5.3	13.8	0.0	5.0	5.0	11.9	0.1	0.0	6.6	2.7	12.7
01/11/80																				
11/11/80					0.186	45.94	2.46	1600	7.8	5.8	15.5	0.0	5.1	6.0	13.7	0.2	0.0	7.6	2.1	15.3
15/11/81		2.32				46.17														
24/11/80					0.176	43.47	3.28	2150	7.4	7.5	18.5	0.0	8.0	4.8	18.9	1.1	0.0	4.5	7.9*	20.4*
01/12/80																				
07/12/80					0.139	34.33	3.19	2020	7.4	7.6	19.0	0.0	5.8	6.2	18.7	0.5	0.0	4.8	12.0	14.4
25/12/80					0.222	54.83	2.55	1780	8.1	9.1	21.7	0.0	3.9	3.7	17.8	0.1	0.0	5.4	5.9*	14.2*
01/01/81																				
07/01/81					0.148	36.56	1.15	750	7.1	3.8	8.5	0.0	2.0	3.1	6.1	0.2	0.0	4.5	2.4*	4.5*

* preliminary corrected data

5. 8. MG 09, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Gharbia drain
Measurement point : MG 09
Remarks : Waterquality data jan-march from observation year 1981

Waterdepth : D = _____ - Hm
Pendulum constant : c_p = _____
Float constant : c_D = _____ + _____ D
Calibration : Q = _____ (D _____) _____

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						8.86	2.28	1530	7.5	9.4	21.1	0.0	4.4	1.8	16.5	0.2	0.0	4.7	8.3	9.9
01/01/80																				
23/01/81						8.23	2.09	1390	8.0	4.2	10.3	0.0	4.8	6.3	10.0	0.4	0.0	4.0	8.2	9.3
01/02/80																				
09/02/81						6.26	6.44	3930	7.2	9.4	28.0	0.0	14.2	14.2	35.4	1.2	0.0	9.8	4.0	51.3
22/02/81						6.26	2.32	1440	7.0	4.1	10.1	0.0	6.5	6.1	10.3	0.5	0.0	4.0	3.7	15.7
01/03/80																				
06/03/81						9.97	1.81	1190	7.6	5.3	12.0	0.0	6.5	0.6	10.0	0.9	0.0	4.0	3.8	10.2
21/03/81						9.97	2.26	1370	7.6	6.2	14.2	0.0	3.8	5.3	13.3	0.2	0.0	3.5	2.2	16.9
01/04/80																				
04/04/81						10.62	1.36	930	8.2	4.2	9.0	0.0	3.1	3.0	7.3	0.2	0.0	3.3	3.5*	6.8*
16/04/80						10.62	1.42	920	7.4	4.5	10.0	0.0	3.5	2.7	8.0	0.2	0.0	3.8	1.6	9.0
01/05/80																				
06/05/80						9.28	2.13	1320	7.8	6.0	13.5	0.0	4.2	4.3	12.3	0.2	0.0	3.6	4.2	13.2
20/05/80						9.28	1.38	910	7.4	2.8	6.3	0.0	3.5	3.7	5.3	1.5	0.0	3.6	2.2	8.2
01/06/80																				
09/06/80						12.63	1.25*	710	7.6	4.1	8.7	0.0	2.1	2.4	6.1	0.2	0.0	4.0	0.7	6.1
22/06/80						12.63	1.92	1290	7.7	6.0	14.1	0.0	2.8	4.7	11.6	0.4	0.0	4.8	6.4	8.3
01/07/80																				
08/07/80						15.53	1.48	960	7.6	4.0	9.3	0.0	2.6	4.6	7.5	0.2	0.0	4.7	1.5	8.7
25/07/80						15.53	1.43	960	8.0	4.8	11.2	0.0	3.2	2.8	8.4	0.1	0.0	5.0	1.7	7.8
01/08/80																				
07/08/80						17.84	1.27	870	7.3	3.6	8.5	0.0	4.7	1.8	6.5	0.1	0.0	5.0	0.9	7.2
30/08/80						17.84	1.53*	910	7.6	5.4	12.1	0.0	3.2	1.8	8.6	0.1	0.0	4.7	1.4	7.6
01/09/80																				
14/09/80						14.46	1.40	930	7.6	4.7	10.8	0.0	3.2	2.4	7.9	0.6	0.0	4.8	0.6	8.7
27/09/80						14.46	1.51	950	7.6	2.2	5.6	0.0	3.2	6.8	4.9	0.1	0.0	5.4	1.5	8.1
01/10/80																				
15/10/80						13.30	1.04	710	7.4	2.2	5.1	0.0	3.7	2.8	3.9	0.1	0.0	4.9	1.0	4.6
01/11/80																				
06/11/80						8.92	1.40	920	7.6	3.6	8.5	0.0	5.5	1.5	6.7	0.3	0.0	5.0	0.4	8.6
20/11/80						8.92	1.40	910	7.4	1.6	3.9	0.0	3.9	6.9	3.7	0.2	0.0	4.0	2.4	8.3
01/12/80																				
30/12/80						10.40	2.28	1530	7.5	9.4	21.1	0.0	4.4	1.8	16.5	0.2	0.0	4.7	8.3	9.9
01/01/81																				
23/01/81						8.86	2.09	1390	8.0	4.2	10.3	0.0	4.8	6.3	10.0	0.4	0.0	4.0	8.2	9.3

* preliminary corrected data

5. 9. MG 10, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Gharbia drain
Measurement point : MG 10
Remarks : Waterquality data jan - march from observation year 1981

Waterdepth : D = _____ - Hm
Pendulum constant : c_P = _____
Float constant : c_D = _____ + _____ D
Calibration : Q = _____ (D _____) _____

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						8.62	3.64-		7.4				4.8	5.6	32.0	0.6	0.0	4.7	16.2	22.1
01/01/80																				
23/01/81						7.67	2.37	1550	7.9	7.4	17.4	0.0	4.8	3.4	15.0	0.4	0.0	4.5	7.8	11.3
01/02/80																				
09/02/81						6.05	8.31	4940	7.4	13.1	35.4	0.0	11.7	18.8	51.1	1.4	0.0	5.0	14.2	63.8
22/02/81						6.05	2.26		7.2				0.2	2.3	15.7	0.3	0.0	4.3		15.8
01/03/80																				
06/03/81						8.66	2.03	1250	7.8	6.5	14.3	0.0	5.9	1.5	12.5	0.2	0.0	3.5	5.2*	11.4*
21/03/81						8.66	3.28*		7.5				5.4	6.0	20.0	0.2	0.0	3.8	4.3	23.5
01/04/80																				
04/04/81						7.90	1.92	1240	7.5	6.1	13.6	0.0	3.4	4.4	12.0	0.2	0.0	3.6	5.8*	10.6*
16/04/80						7.90	2.29	1430	7.6	6.0	14.0	0.0	4.5	5.0	13.0	0.2	0.0	4.0	5.2	13.5
01/05/80																				
06/05/80						7.94	2.04	1340	7.7	7.7	16.9	0.0	4.4	2.1	13.8	0.2	0.0	4.0	6.1	10.4
20/05/80						7.94	2.04	1140	7.2	5.5	12.2	0.0	2.7	4.6	10.5	0.4	0.0	3.6	3.1	11.5
01/06/80																				
09/06/80						13.14	2.30	1440	7.8	7.8	17.9	0.0	2.6	4.9	15.2	0.3	0.0	4.2	3.8	15.0
22/06/80						13.14	2.83	1810	7.6	8.9	21.0	0.0	3.0	6.2	19.0	0.2	0.0	4.6	8.7	15.1
01/07/80																				
08/07/80						14.76	2.73	1730	7.7	8.1	19.5	0.0	4.7	4.8	17.7	0.3	0.0	4.7	5.3	17.5
25/07/80						14.76	2.21	1430	7.6	7.0	16.8	0.0	4.2	3.8	14.0	0.2	0.0	5.1	4.1	13.0
01/08/80																				
07/08/80						15.52	1.91-		7.5				4.2	4.3	10.7*	0.2	0.0	5.2	1.2*	13.0
30/08/80						15.52	2.00	1290	7.4	6.4	15.2	0.0	3.2	4.4	12.4	0.2	0.0	5.1	2.3	12.8
01/09/80																				
14/09/80						13.54*	2.73	1760	7.5	8.6	20.7	0.0	3.2	5.6	18.0	0.3	0.0	5.1	8.7	13.3
27/09/80						13.54*	2.82	1790	7.6	7.6	19.2	0.0	3.9	6.6	17.5	0.2	0.0	5.6	6.0	16.6
01/10/80																				
15/10/80						12.40	1.69	1130	7.6	2.5	6.5	0.0	5.2	5.8	5.8	0.1	0.0	6.4	1.5*	9.0*
01/11/80																				
06/11/80						7.49	1.00	650	7.5	2.9	6.1	0.0	3.2	1.8	4.6	0.4	0.0	3.2	2.3*	4.5*
20/11/80						7.49	2.49	1570	7.2	6.5	16.7	0.0	4.8	5.3	14.6	0.2	0.0	6.4	1.5	17.0
01/12/80																				
30/12/80						9.47	3.64-		7.4				4.8	5.6	24.8*	0.6	0.0	4.7	9.0*	22.1
01/01/81																				
23/01/81						8.62	2.37	1550	7.9	7.4	17.4	0.0	4.8	3.4	15.0	0.4	0.0	4.5	7.8	11.3

* preliminary corrected data

5. 10. WE 10, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Edko drain
Measurement point : WE 10
Remarks : Water quality data of Jan. - Febr. are from 1981

Waterdepth : D = ... - Hm
Pendulum constant : c_P = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						2.44**	6.37	4750	7.9	19.0	47.3	0.0	3.7	12.8	54.6	0.7	0.0	4.7	22.6*	44.5*
01/01/80																				
I/01/80						1.91														
20/01/81						2.45	7.55	5500	7.4	25.5	69.9	0.0	3.8	11.3	70.0	0.9	0.0	10.0	27.4	48.6
III/01/80						1.64														
01/02/80																				
03/02/81						2.18	13.29	9620	8.0	23.2	68.1	0.0	16.4	27.1	108.0	0.9	0.0	8.2	44.9*	99.3*
08/02/81						2.18	4.75-		7.0				6.5	20.8	28.0	0.7	0.0	7.3	16.4	32.3
II/02/80						1.96														
25/02/81						1.86	6.43*		6.9				6.5	11.4	44.0	0.6	0.0	5.0	6.7	50.8
01/03/80																				
I/03/80						1.42														
12/03/80						2.60	7.82	4900	7.7	19.0	48.7	0.0	6.8	13.2	60.0	1.0	0.0	5.0	14.6	61.4
24/02/80						5.64	3.91	2540	7.2	13.1	35.1	0.0	4.5	5.5	29.4	0.8	0.0	9.6	0.4	30.2
01/04/80																				
09/04/80						4.42	4.93	3450	7.4	14.8	37.0	0.0	4.5	10.2	40.0	0.8	0.0	5.0	15.0	35.5
II/04/80						4.46														
22/04/80						4.62	4.67	2960	7.7	21.8	42.5	0.0	3.2	3.4	39.6	0.6	0.0	2.8	15.0	29.0
01/05/80																				
I/05/80						5.05														
13/05/80						5.47	3.83	2290	7.7	9.4	24.1	0.0	4.7	8.8	24.4	0.4	0.0	5.6	7.1*	25.6*
21/05/80						4.99	3.74	2280	6.7	9.2	23.7	0.0	7.1	6.4	24.0	0.2	0.0	5.6	1.9	30.2
01/06/80																				
04/06/80						6.35	3.15	1910	7.6	6.9	17.2	0.0	3.8	8.8	17.2	1.8	0.0	4.8	6.1*	20.7*
14/06/80						6.06	4.30	2580	7.9	10.1	24.4	0.0	3.0	11.7	27.5	1.1	0.0	3.7	6.2	33.4
III/06/80						6.81														
01/07/80																				
02/07/80						8.95	4.00	2630	7.6	10.1	27.5	0.0	5.1	9.3	27.0	0.6	0.0	8.0	6.4	27.6
16/07/80						8.84	3.55	2280	7.8	11.7	29.6	0.0	5.1	4.4	25.5	0.6	0.0	6.8	6.3	22.5
III/07/80						8.93														
01/08/80																				
02/08/80						9.42	3.45	2160	7.7	10.9	27.5	0.0	4.7	5.3	24.3	0.2	0.0	6.5	4.1	23.9
18/08/80						9.09	3.28	2080	7.6	9.9	24.9	0.0	3.7	6.9	22.2	0.6	0.0	6.1	6.4	20.4
III/08/80						8.94														
01/09/80																				
02/09/80						10.28	2.91	1950	7.4	10.4	25.4	0.0	4.6	3.9	21.4	0.4	0.0	5.9	6.5	17.9
18/09/80						10.29	3.28	2070	7.6	10.5	25.8	0.0	3.4	6.1	22.9	0.5	0.0	5.6	5.9	21.4
27/09/80						10.03	3.28	2110	7.7	7.8	20.8	0.0	4.7	8.3	20.0	0.4	0.0	6.8	6.3	20.3
01/10/80																				
I/10/80						7.09														
13/10/80						5.98	3.55	2200	7.5	8.8	23.8	0.0	4.7	8.3	22.5	0.2	0.0	7.8	1.6	26.3
III/10/80						5.22														
01/11/80																				
02/11/80						5.19	4.00	2510	7.5	9.4	25.5	0.0	4.5	9.5	25.0	1.1	0.0	7.4	6.3*	26.4*
16/11/80						6.24	4.55	2940	8.0	10.8	27.7	0.0	6.8	8.7	30.0	0.2	0.0	5.3	9.5*	30.9*
III/11/80						5.41														
01/12/80																				
03/12/80						4.91	5.00	3170	7.4	15.6	37.7	0.0	4.2	7.3	37.5	1.1	0.0	4.8	15.9*	29.4*
17/12/80						2.60**	6.55	4610	7.1	19.5	48.1	0.0	5.2	10.1	54.0	0.8	0.0	4.7	19.5*	45.9*
30/12/80						2.44**	6.37	4750	7.9	19.0	47.3	0.0	3.7	12.8	54.6	0.7	0.0	4.7	22.6*	44.5*
01/01/81																				
I/01/81						1.91														
20/01/81						2.45	7.55	5500	7.4	25.5	69.9	0.0	3.8	11.3	70.0	0.9	0.0	10.0	27.4	48.6

* preliminary corrected data

** estimated (missing) data

5.11. WE 11, calculation sheet with preliminary corrected data

Observation year : 1980
Catchment area : Edko drain
Measurement point : WE 11
Remarks : Water quality data of Jan- Febr. are from observation year 1981

Waterdepth : D = ... - Hm
Pendulum constant : c_P = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						4.16	3.37	2280	7.6	11.4	26.8	0.0	3.2	6.9	25.6	0.5	0.0	4.3	10.7	21.2
01/01/80																				
1/01/80						2.01														
20/01/81						3.09	28.21	20560	7.0	57.8	166.0	0.0	11.0	36.0	280.0	2.7	0.0	8.5	116.3	204.9
III/01/80						1.93														
01/02/80																				
03/02/81						2.53	22.75*	14830	7.6	37.2	112.9	0.0	20.4	30.6	188.0	0.9	0.0	10.8	73.1	156.0
08/02/81						2.53	12.56		7.5				10.4	16.4	95.0	3.0	0.0	6.5	14.3	104.0
II/02/80						4.17														
25/02/81						4.78	3.40*		7.2				4.6	6.0	20.0	0.5	0.0	4.4	3.4	23.3
01/03/80																				
I/03/80						4.69														
12/03/80						8.23	2.53*	1380	7.7	8.4	17.4	0.0	3.0	3.7	15.3	0.3	0.0	3.0	3.5	15.8
24/03/80						7.75	2.21	1460	7.4	7.7	19.3	0.1	3.5	3.6	14.6	0.5	0.0	7.2	1.5	13.5
01/04/80																				
09/04/80						8.01	2.55	1590	7.4	7.5	17.4	0.0	3.8	5.3	16.0	0.5	0.0	4.0	4.6	17.0
II/04/80						9.78														
22/04/80						9.78	1.79	1160	7.9	6.3	13.0	0.0	3.4	3.1	11.4	0.2-	0.0	2.8	5.3	10.0
01/05/80						*														
I/05/80						9.61														
13/05/80						10.27	1.96	1170	7.9	5.1	12.0	0.0	3.7	4.3	10.2	0.4	0.0	4.4	2.1	12.1
21/05/80						6.08	1.87	1230	6.7	4.2	10.6	0.0	7.4	2.0	9.2	0.2	0.0	5.2	3.5	10.1
01/06/80																				
04/06/80						9.06	1.21	780	7.4	2.4	5.7	0.0	3.5	3.7	4.6	0.2	0.0	4.4	1.4	6.2
14/06/80						6.87	2.04	1280	7.9	4.0	9.4	0.0	5.0	5.7	9.2	0.5	0.0	3.6	5.4	11.4
III/06/80						11.02														
01/07/80																				
02/07/80						10.71	1.87	1230	7.6	5.5	13.8	0.0	4.1	3.5	10.7	0.4	0.0	6.8	0.4	11.5
16/07/80						10.96	1.41	950	7.6	4.7	11.1	0.0	2.0	3.8	8.0	0.3	0.0	5.8	1.4	6.9
III/07/80						7.47														
01/08/80																				
02/08/80						7.28	1.65	1080	7.2	5.3	12.7	0.0	3.2	3.4	9.7	0.2	0.0	5.4	1.7	9.4
18/08/80						11.45	1.57	1040	7.3	4.9	11.6	0.0	3.7	2.8	8.8	0.4	0.0	5.3	1.7	8.7
III/08/80						11.38														
01/09/80																				
02/09/80						11.60	1.53	1010	7.4	3.9	9.6	0.0	3.7	3.8	7.5	0.4	0.0	5.9	0.8	8.7
18/09/80						11.10	1.82	1210	7.8	6.0	14.5	0.0	5.7	1.1	11.0	0.4	0.0	6.0	1.5	10.7
27/09/80						9.18	2.00	1290	7.3	5.4	13.3	0.0	4.2	4.3	11.2	0.3	0.0	5.2	3.5	11.3
01/10/80																				
I/10/80						10.87														
13/10/80						5.61	1.82	1150	8.4	5.0	12.0	0.0	4.2	3.8	10.0	0.2	0.0	4.8	1.2	12.2
III/10/80						5.25														
01/11/80																				
02/11/80						3.63	1.67	1110	7.2	5.0	12.2	0.0	3.7	3.3	9.3	0.4	0.0	6.2	1.6*	8.9*
16/11/80						4.55	2.18	1450	7.8	5.5	13.3	0.0	4.0	5.5	12.0	0.5	0.0	4.6	5.0*	12.4*
III/11/80						5.15														
01/12/80																				
03/12/80						5.05	2.00	1350	7.5	6.7	15.5	0.0	3.2	3.9	12.7	0.4	0.0	4.4	4.5*	11.3*
17/12/80						4.46	3.64	2340	7.1	11.1	28.1	0.0	4.8	6.2	26.0	0.5	0.0	6.2	5.3	26.0
30/12/80						4.16	3.37	2280	7.6	11.4	26.8	0.0	3.2	6.9	25.6	0.5	0.0	4.3	10.7	21.2
01/01/81																				
I/01/81						2.01														
20/01/81						3.09	28.21	20560	7.0	57.8	166.0	0.0	11.0	36.0	280.0	2.7	0.0	8.5	116.3	204.9

* priliminary corrected data

Annex 6: CALCULATION SHEETS AFTER DATA CHECKING AND INTERPOLATION

6. 1. FB 03, Batts drain at Furgus

6. 2. FB 04, Roda drain

6. 3. EB 07, Bahr Baqar drain at 'Kubri Saud'

6. 4. EH 11, Bahr Hadus drain at 'Kubri Bahr Hadus'

6. 5. EH 13, Bahr Hadus drain at 'Outfall'

6. 6. MG 09, pump station No. 4

6. 7. WE10, Edko pump station

6. 8. WE 11, Bosseili pump station

6.1. FB 03, calculation sheet after data checking and interpolation

Observation year : 1980
Catchment area : Batta drain
Measurement point : FB 03
Remarks :

Waterdepth : D = 3.88 - Hm
Pendulum constant : c_p = 0.630
Float constant : c_D = 0.879 + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
23/12/79	9	1.40	11.06	0.273	-	3.39*	1.18	800	8.0	3.3	7.8	0.0	3.1	2.7	5.6	0.3	0.0	5.5	0.6	5.6
01/01/80	8					3.61			8.1				3.4	4.2	5.6	0.2	0.0	4.8	2.2	6.4
09/01/80	14	1.58	12.86	0.336	-	3.80	1.45*	940	8.3	2.7	6.4	0.0	3.6	5.3	5.6	0.1	0.0	4.2	3.4	7.0
23/01/80	9	0.51	3.08	0.198	-	0.54	4.83		7.4				6.6	10.1	35.0	0.7	0.0	5.3	17.0	30.1
01/02/80	5					0.56			7.4				7.8	11.1	30.4	0.7	0.0	7.6	16.3	26.1
06/02/80	18	0.46	2.78	0.233	-	0.57	4.17*	3140	7.4	8.8	25.3	0.0	8.5	11.7	28.0	0.7	0.0	8.8	16.1	24.0
24/02/80	6	1.69	13.96	0.346	-	4.25	1.09*	640	7.6	3.7	7.5	0.0	2.6	1.4	5.2	0.4	0.0	3.5	0.8	5.3
01/03/80	13					3.79			7.6				3.0	1.8	5.5	0.3	0.0	3.9	1.2	5.5
14/03/80	18	1.16	8.66	0.367	-	2.79	1.43	950	7.8	3.3	8.1	0.0	4.5	3.1	6.5	0.1	0.0	5.2	2.8	6.2
01/04/80	3				-	2.58*			7.5				4.1	1.5	7.2	0.3	0.0	3.8	3.8	5.5
04/04/80	14	1.08	7.86	0.470	1.353	2.55*	1.28	870	7.5	4.5	9.6	0.0	4.0	1.2	7.3	0.3	0.0	3.5	3.9	5.4
18/04/80	12	1.08	7.86	0.409	0.622	2.71*	1.45	990	7.4	4.9	10.9	0.0	3.0	3.2	8.6	0.2	0.0	4.0	4.0	7.0
30/04/80	1	1.11	8.16	0.452	0.698	2.58*	1.22	810	7.6	4.4	9.6	0.0	2.6	2.4	7.0	0.2	0.0	4.0	2.2	6.0
01/05/80	17					2.57*			7.6				2.6	2.4	7.1	0.2	0.0	4.0	2.3	6.0
18/05/80	14	1.03	7.36	0.451	0.762	2.40*	1.51	1000	8.0	5.3	11.7	0.0	3.0	2.7	9.0	0.3	0.0	4.0	4.4	6.6
01/06/80	1					1.62*			7.8				3.7	1.5	7.2	0.2	0.0	4.7	1.3	6.6
02/06/80	26	0.85	5.56	0.380	-	1.56*	1.24	840	7.8	4.3	9.8	0.0	3.8	1.4	7.0	0.2	0.0	4.8	1.0	6.6
28/06/80	3	0.94	6.46	0.428	0.597	1.71	1.33	900	7.3	3.8	8.7	0.0	4.5	1.8	6.7	0.3	0.0	4.4	3.3	5.6
01/07/80	10					1.74			7.4				4.3	1.8	8.2	0.3	0.0	4.3	4.4	5.9
11/07/80	14	0.86	5.66	0.383	0.579	1.82	1.78*	1260	7.7	7.9	17.1	0.0	3.6	1.8	13.0	0.2	0.0	4.1	7.6	6.9
25/07/80	7	1.02	7.26	0.345	0.540	2.17	1.35		7.5				3.2	2.4	7.8	0.2	0.0	2.1	5.8	5.7
01/08/80	31					2.33			7.5				3.2	2.3	7.8	0.2	0.0	2.8	4.9	5.8
01/09/80	16					3.05			7.6				3.2	1.9	7.7	0.4	0.0	5.0	2.2	6.0
17/09/80	14	1.38	10.86	0.313	0.568	3.42	1.31	910	7.6	4.9	11.3	0.8	3.2	1.8	7.7	0.4	0.0	5.8	1.2	6.1
01/10/80	10					3.26*			7.7				3.5	2.6	8.6	0.3	0.0	6.5	1.7	6.8
11/10/80	21	1.22	9.26	0.291	0.478	3.15*	1.66	1130	7.9	5.0	12.5	0.0	3.7	3.3	9.3	0.2	0.0	7.0	2.1	7.4
01/11/80	3					1.97			7.9				3.7	3.3	9.9	0.2	0.0	7.0	2.7	7.4
04/11/80	5	0.91	6.16	0.338	0.528	1.80	1.68	1180	7.9	5.3	13.4	0.0	3.7	3.3	10.0	0.2	0.0	7.0	2.8	7.4
09/11/80	22	1.12	8.26	0.308	0.475	2.17	1.58	1070	7.8	4.8	11.7	0.0	3.9	2.8	8.7	0.2	0.0	6.4	3.0	6.2
01/12/80	16					2.67			7.4				4.1	3.5	10.7	0.3	0.0	4.4	5.6	8.6
17/12/80	15	1.21	9.16	0.353	0.598	3.03	2.00	1380	7.3	5.9	13.0	0.0	4.2	3.8	11.7	0.4	0.0	3.4	6.8*	9.9*
01/01/81	16					3.01			7.3				4.4	5.0	12.1	0.3	0.0	4.1	5.9	11.8
17/01/81		1.16	8.66	0.375	0.624	2.99	2.37	1490	7.3	5.4	13.3	0.0	4.6	6.3	12.5	0.2	0.0	4.8	5.0	13.8

* corrected or estimated data

6.2. EB 04, calculation sheet after data checking and interpolation

Observation year : 1980
Catchment area : Batta drain
Measurement point : FB 04
Remarks :

Waterdepth : D = 4.04 - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
17/12/80*	15	0.93	6.01	0.668		4.01	2.18	1530	7.2	8.3	18.2	0.0	3.2	3.4	15.0	0.4	0.0	4.0	14.3	3.7
01/01/80	8					4.21*			7.6				4.7	5.2	13.7	0.3	0.0	4.5	10.6	8.8
09/01/80	14	0.55	3.35	0.865		4.31	2.47	1590	8.4	5.4	13.5	0.0	5.4	6.1	13.0	0.2	0.0	4.7	8.7	11.3
23/01/80	9	0.01	0.45	0.264		0.12	8.42	5980	7.4	16.8	49.3	0.0	6.8	23.1	65.0	0.7	0.0	9.3	33.2	53.1
01/02/80	5					0.14			7.5				12.3	16.4	67.4	0.6	0.0	6.9	37.9	51.9
06/02/80	18	-0.02	0.33	0.454		0.15	8.25	6160	7.6	18.2	49.6	0.0	14.8	13.4	68.5	0.6	0.0	5.8	40.1	51.4
24/02/80	6	0.67	4.19	1.143		4.79	1.87	1250	7.6	4.9	11.7	0.0	5.2	3.3	10.2	0.4	0.0	4.4	5.6	9.1
01/03/80	13					4.25			7.7				5.2	4.1	10.8*	0.4	0.0	5.0	6.4*	9.1
14/03/80	18	0.44	2.65	1.159		3.07	2.13	14.00	7.9	3.7	10.1	0.0	5.0	6.9	12.7*	0.2	0.0	7.2	8.5*	9.1
01/04/80	3					2.74			7.5				5.0	3.8	10.4	0.4	0.0	4.7	7.4	7.5
04/04/80	14	0.44	2.65	1.014		2.69	1.87	1240	7.5	4.9	11.6	0.0	5.0	3.2	10.0	0.4	0.0	4.2	7.2*	7.2*
18/04/80	12	0.50	3.01	0.901		2.71	1.42	930	7.4	4.9	10.8	0.0	3.0	2.7	8.3	0.2	0.0	4.0	4.2*	6.0
30/04/80	1	0.51	3.07	0.901		2.77	1.44	970	7.6	6.5	13.7	0.0	2.6	1.9	9.8	0.2	0.0	4.0	3.3	7.2
01/05/80	17					2.75			7.6				2.6	1.9	9.8	0.2	0.0	4.1	3.2*	7.2*
18/05/80	14	0.45	2.71	0.911		2.47	1.48	970	7.9	5.2	12.0	0.0	3.0	2.7	8.8	0.2	0.0	5.2	3.2*	6.3
01/06/80	1					1.03			7.9				5.0	3.3	13.7	0.3	0.0	5.5	6.9	9.9
02/06/80	26	0.15	1.15	0.807		0.93	2.38	1570	7.9	7.0	17.2	0.0	5.4	3.4	14.6	0.3	0.0	5.6	7.5	10.6
28/06/80	3	0.20	1.40	0.675		0.95	2.72	1770	7.4	8.2	19.8	0.0	4.7	4.5	17.6	0.4	0.0	5.0	9.0	13.2
01/07/80	10					1.00*			7.4				4.6	4.1	18.2	0.4	0.0	4.9	9.3	13.1
11/07/80	14	0.22	1.50	1.112		1.16*	2.81	1820	7.4	10.5	23.9	0.0	4.2	3.0	20.0	0.4	0.0	4.5	10.2	12.9
25/07/80	7	0.35	2.15	0.777		1.67	2.73+		7.4				4.7	4.3	16.2	0.2	0.0	4.4	8.5	12.5
01/08/80	31					1.92			7.5				4.6	3.9	16.0	0.2	0.0	4.5	8.4	11.8
01/09/80	16					3.04			7.6				4.3	3.0	15.5	0.4	0.0	4.7	8.3	10.2
17/09/80	14	0.95	6.15	0.587		3.61	2.28	1520	7.7	8.2	19.0	0.0	4.2	2.8	15.4	0.4	0.0	4.8	8.3	9.7
01/10/80	10					3.83			7.9				5.2	2.9	13.9	0.3	0.0	6.0	7.0	9.3
11/10/80	21	0.90	5.80	0.686		3.98	2.18	1490	8.0	6.2	15.8	0.0	5.8	3.0	13.0	0.2	0.0	6.7	6.2	9.1
01/11/80	3					2.40*			8.0				5.8	3.0	13.4	0.2	0.0	6.7	6.6	9.1
04/11/80	5	0.76	4.82	0.691		2.17	2.22	1520	8.0	6.4	16.4	0.0	5.8	3.0	13.5	0.2	0.0	6.7	6.7	9.1
09/11/80	22	0.75	4.75	0.742		3.52	2.27	1530	7.9	6.3	15.9	0.0	5.5	3.5	13.3	0.4	0.0	6.4	7.2	9.1
01/12/80	16					3.60			7.4				4.1	3.4	14.3	0.4	0.0	4.9	7.6*	9.7*
17/12/80	15	0.93	6.01	0.668		4.01	2.18	1530	7.2	8.3	18.2	0.0	3.2	3.4	15.0	0.4	0.0	4.0	7.9*	10.1*
01/01/81	16					3.88			7.2				4.5	3.5	18.3	0.4	0.0	4.4	8.2	14.1
17/01/81		0.88	5.66	0.661		3.74	3.35*		7.2				5.9	3.6	22.0	0.4	0.0	4.8	8.5	16.6

* corrected or estimated data

6. 3. EB 07, calculation sheet, after data checking and interpolation

Observation year : 1980
Catchment area : Bahr baqar drain
Measurement point : EB 07
Remarks :

Waterdepth : D = 5. 02 - Hm
Pendulum constant : c_p = ...
Float constant : c_D = - 1. 23 + 0. 667 D
Calibration : Q = ... (D .....)

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79	12	3. 27	104. 97	0. 424		42. 26	1. 02	730	7. 1	3. 2	7. 3	0. 3	4. 4	0. 6	5. 0	0. 2	0. 0	5. 3	0. 8	4. 1
01/01/80	5					32. 77			7. 2				3. 9	1. 7	5. 2	0. 3	0. 0	5. 2	2. 0	3. 9
06/01/80	21	3. 04	93. 52	0. 387		28. 32	1. 18	820	7. 2	3. 1	7. 3	0. 0	3. 6	2. 4	5. 4	0. 3	0. 0	5. 1	2. 8	3. 8
27/01/80	5	2. 92	87. 54	0. 453		28. 40	1. 46	1010	7. 6	3. 0	7. 6	0. 0	4. 6	3. 8	6. 1	0. 1	0. 0	7. 7	0. 8	6. 1
01/02/80	9					24, 69			7. 6				4. 6	3. 7	6. 0	0. 1	0. 0	7. 6	0. 9	5. 9
10/02/80	15	2. 74	79. 04	0. 382		18. 00	1. 45	970	7. 6	2. 9	7. 4	0. 0	4. 7	3. 3	5. 7	0. 2	0. 0	7. 4	1. 2	5. 3
25/02/80	5	3. 05	94. 01	0. 448	0. 607	33. 81	0. 99*	580	7. 8*	1. 7	3. 8	0. 0	3. 2*	2. 7*	2. 9*	0. 1*	0. 0	4. 0*	2. 5*	2. 4*
01/03/80	8					32. 57			7. 8				3. 9	3. 6	2. 3	0. 1	0. 0	4. 4	2. 4	3. 1
09/03/80	14	2. 96	89. 53	0. 460	0. 562	30. 59	1. 17	780	7. 7	0. 5	1. 4	0. 0	5. 2	5. 2	1. 2	0. 2	0. 0	5. 2	2. 3	4. 3
23/03/80	9	2. 91	87. 04	0. 313	0. 554	26. 27*	1. 28*	1080	7. 5*	3. 7	9. 9	3. 5	3. 7	3. 6	7. 0	0. 2	0. 0	10. 8	0. 1	3. 6
01/04/80	12					25. 64			7. 5				3. 6	3. 4	6. 2	0. 2	0. 0	6. 8	2. 4	4. 2
13/04/80	7	2. 84	83. 66	0. 447	0. 522	24. 79	1. 16	770	7. 5	2. 8	4. 7	0. 0	3. 5	3. 1	5. 1	0. 3	0. 0	1. 2	5. 8	5. 0
20/04/80	11	2. 81	82. 22	0. 532	0. 827	22. 22*	1. 12	800	7. 3	3. 3	7. 9	0. 7	3. 0	2. 7	5. 5	0. 1	0. 0	6. 4	0. 9	4. 0
01/05/80	3					21. 25			7. 2				3. 2	2. 5	6. 4	0. 1	0. 0	3. 9	3. 5	4. 8
04/05/80	22	2. 81	82. 22	0. 397	0. 543	20. 98	1. 22	820	7. 2	3. 9	8. 3	0. 0	3. 2	2. 4	6. 6	0. 1	0. 0	3. 2	4. 1	5. 0
26/05/80	6	2. 88	85. 57	0. 313	0. 539	23. 13*	1. 00	700	7. 4	1. 7	4. 1	0. 0	3. 2	3. 4	3. 0	0. 4	0. 0	5. 6	1. 0	3. 4
01/06/80	2					23. 48			7. 1				2. 7	3. 5	4. 0	0. 2	0. 0	6. 8	0. 1	3. 5
03/06/80	12	2. 90	86. 54	0. 388	0. 537	23. 60	1. 07	760	7. 0	2. 5	6. 2	1. 1	2. 6	3. 5	4. 3	0. 2	0. 0	7. 2	0. 0	3. 5
15/06/80	14	2. 86	84. 61	0. 465	0. 725	26. 60	1. 04	710	7. 4	2. 3	5. 5	0. 0	4. 4	1. 7	4. 0	0. 2	0. 0	5. 2	2. 4*	2. 7*
29/06/80	2	2. 88	85. 57	0. 464	0. 684	27. 38	1. 13	710	7. 4	2. 3	5. 5	0. 0	4. 4	1. 7	4. 0	0. 2	0. 0	5. 2	0. 4	4. 7
01/07/80	15					27. 26			7. 4				4. 1	1. 7	4. 5	0. 2	0. 0	5. 1	0. 5	4. 9
16/07/80	15	2. 95	89. 03	0. 402	0. 661	26. 95	1. 36*	820	7. 3	5. 7	11. 7	0. 1	2. 2	1. 8	8. 0	0. 2	0. 0	4. 1	1. 8	6. 3
31/07/80	1	3. 08	95. 51	0. 403	0. 715	31. 67	1. 04	720	8. 1	2. 7	6. 3	0. 0	3. 4	2. 3	4. 5	0. 2	0. 0	5. 4	0. 8	4. 2
01/08/80	17					31. 50			8. 1				3. 4	2. 3	4. 5	0. 2	0. 0	5. 4	0. 8	4. 2
18/08/80	14	-	-	-	-	28. 52*	1. 02	720	8. 6	2. 3	5. 5	0. 0	3. 2	2. 9	4. 0	0. 2	0. 0	5. 4	1. 4	3. 6
01/09/80	21					30. 52			7. 7				3. 2	2. 7	4. 4	0. 2	0. 0	5. 3	1. 4	3. 8
22/09/80	9	3. 22	102. 48	0. 357	0. 551	33. 52	1. 06	750	7. 4	3. 0	7. 0	0. 0	3. 2	2. 4	5. 0	0. 2	0. 0	5. 4	1. 3	4. 1
01/10/80	3					34. 93			7. 3				3. 6	2. 3	4. 4	1. 0	0. 0	6. 2	1. 4	3. 7
04/10/80	23	3. 18	100. 49	0. 396	0. 599	35. 40	1. 13	830	7. 3	2. 4	6. 0	0. 4	3. 7	2. 3	4. 2	1. 2	0. 0	6. 4	1. 4	3. 6
27/10/80	5	3. 09	96. 01	0. 302	0. 536	24. 05	1. 15	760	7. 3	1. 6	3. 9	0. 0	4. 2	3. 3	3. 1	0. 6	0. 0	5. 0	0. 9	5. 3
01/11/80	10					27. 72			7. 4				4. 4	3. 0	3. 7	0. 4	0. 0	5. 8	0. 8	4. 9
11/11/80	13	3. 04	93. 52	0. 471	0. 726	35. 07	1. 16	860	7. 8	2. 4	6. 2	0. 0	4. 6	2. 7	4. 6	0. 2	0. 0	7. 0	0. 8	4. 3
24/11/80	7	3. 10	96. 50	0. 325	0. 522	26. 23	1. 66	1190	7. 4	3. 5	8. 9	0. 0	4. 6	3. 1	6. 9	2. 0	0. 0	6. 4	6. 0	4. 2
01/12/80	6					25. 38			7. 3				4. 9	4. 0	5. 7	1. 1	0. 0	6. 7	3. 0	6. 0
07/12/80	17	3. 07	95. 01	0. 318	0. 411	24. 66	1. 47	1040	7. 3	2. 1	5. 6	0. 0	5. 2	4. 8	4. 7	0. 2	0. 0	7. 0	0. 2*	7. 7*
25/12/80	8	3. 32	107. 46	0. 373	0. 449	39. 40	1. 40	970	7. 9	4. 4	10. 5	0. 0	3. 2	3. 0	7. 7	0. 1	0. 0	5. 8	3. 7	4. 5
01/01/81	6					30. 61			7. 3				2. 9	3. 8	7. 0	0. 6	0. 0	6. 2	3. 9	4. 2
07/01/81		3. 03	93. 03	-	0. 486	24. 02	1. 27*	1030	7. 0	3. 2	8. 1	0. 0	2. 5	4. 8	6. 1	1. 2	0. 0	6. 6	4. 2	3. 8

* corrected or estimated data

6. 4. EH 11, calculation sheet after data checking and interpolation

Observation year : 1980
Catchment area : Bahr Hadus drain
Measurement point : EH 11
Remarks :

Waterdepth : D = 6. 23 - Hm
Pendulum constant : c_p = 0. 949
Float constant : c_D = 0. 437 + ... D
Calibration : Q = ... (D .....)

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
20/12/79	12	3. 86	186. 75	0. 511	-	41. 70	1. 57	970	7. 4	3. 9	8. 9	0. 0	5. 5	2. 2	7. 7	0. 2	0. 0	3. 6	6. 2*	5. 8*
01/01/80	5					32. 83			7. 4				4. 7	5. 2	11. 5	0. 2	0. 0	4. 0	5. 4	12. 2
06/01/80	21	3. 71	177. 27	0. 376	-	29. 13	2. 52	1550	7. 4	5. 8	14. 0	0. 0	4. 2	7. 0	13. 7	0. 2	0. 0	4. 2	4. 9	16. 0
27/01/80	5	3. 46	161. 47	0. 298	-	21. 03	3. 83	2390	7. 5	6. 9	18. 3	0. 0	9 5	8. 6	20. 9	0. 2	0. 0	5. 1	6. 8	27. 3
01/02/80	9					19. 03			7. 5				9. 3	9. 2	22. 1	0. 2	0. 0	5. 4	7. 0	28. 4
10/02/80	15	3. 47	162. 10	0. 218	-	15. 44	4. 51	2740	7. 6	8. 0	21. 7	0. 0	8. 9	10. 8	25. 0	0. 2	0. 0	6. 2	7. 5	31. 2
25/02/80	5	3. 85	186. 11	0. 635	0. 670	32. 43*	2. 04*	1190	7. 9*	4. 9	10. 5	0. 0	3. 8*	4. 7*	10. 2*	0. 1*	0. 0	2. 6*	6. 6*	9. 6*
01/03/80	8					34. 93			7. 8				4. 4	5. 6	9. 7	0. 1	0. 0	3. 0	7. 7	9. 1
09/03/80	14	3. 75	179. 79	0. 450	0. 522	38. 92	1. 87	1180	7. 7	2. 7	6. 4	0. 0	5. 2	6. 8	9. 0*	0. 2	0. 0	3. 6	9. 1*	8. 5
23/03/80	9	3. 57	168. 42	0. 430	0. 422	29. 47	2. 31	1470	7. 6*	4. 7	12. 7	0. 0	5. 2	6. 4	11. 2	0. 2	0. 0	8. 0	0. 2	14. 8
01/04/80	12					31. 89			7. 5				5. 1	5. 5	12. 0	0. 2	0. 0	8. 6	0. 0	14. 2
13/04/80	7	3. 72	177. 90	0. 514	0. 476	35. 12	2. 21	1510	7. 4	6. 0	16. 1	0. 0	5. 0	4. 5	13. 0	0. 3	0. 0	9. 2	6. 3	13. 5
20/04/80	11	3. 71	177. 27	0. 476	0. 470	34. 55	2. 30	1430	7. 7	6. 1	14. 6	0. 0	4. 5	4. 5	13. 0	0. 2	0. 0	4. 4	6. 3	11. 5
01/05/80	3					31. 05			7. 5				4. 7	5. 1	14. 4	0. 2	0. 0	2. 8	7. 8	13. 8
04/05/80	22	3. 60	170. 31	0. 307	0. 426	30. 09	2. 50	1550	7. 4	6. 6	13. 9	0. 0	4. 7	5. 3	14. 8	0. 2	0. 0	2. 3	8. 2	14. 5
26/05/80	6	3. 70	176. 63	0. 423	0. 542	39. 70	1. 60	1030	7. 6	4. 3	10. 0	0. 0	5. 0	2. 6	8. 3	0. 1	0. 0	4. 4	5. 6*	6. 0*
01/06/80	2					28. 44			7. 4				4. 1	6. 1	10. 1	0. 2	0. 0	7. 3	3. 8	9. 4
03/06/80	12	3. 62	171. 58	0. 376	0. 347	24. 69	2. 22	1500	7. 3	4. 6	12. 6	0. 0	3. 6	8. 0	11. 0	0. 2	0. 0	8. 8	2. 8	11. 2
15/06/80	14	3. 74	179. 16	0. 518	0. 576	32. 50*	2. 38	1520	7. 4	7. 1	17. 4	0. 0	4. 4	4. 4	14. 8	0. 2	0. 0	5. 6	3. 2	15. 0
29/06/80	2	3. 56	167. 79	0. 289	0. 270	29. 86*	2. 55*		7. 4				3. 4	3. 4	15. 7	0. 4	0. 0	5. 6	2. 3	15. 0
01/07/80	15					31. 14			7. 4				3. 4	3. 6	15. 9	0. 4	0. 0	5. 5	2. 8	15. 0
16/07/80	15	3. 88	188. 01	0. 540	0. 523	40. 78	2. 55	1630	7. 2	8. 5	20. 0	0. 0	3. 1	4. 9	17. 0	0. 5	0. 0	4. 8	6. 0	14. 7
31/07/80	1	3. 93	191. 17	0. 523	0. 561	44. 48	2. 55	1620	7. 8	7. 1	17. 6	0. 0	4. 7	4. 8	15. 5	0. 2	0. 0	5. 4	5. 8	14. 0
01/08/80	17					43. 91			7. 8				4. 7	4. 8	15. 5	0. 2	0. 0	5. 4	5. 8	14. 0
18/08/80	14	3. 90	189. 27	0. 463	0. 437	34. 30	2. 55	1650	7. 4	6. 8	16. 8	0. 0	5. 0	4. 5	14. 8	1. 1	0. 0	5. 3	5. 8	14. 3
01/09/80	21					38. 11			7. 5				4. 9	4. 6	14. 9	0. 6	0. 0	4. 9	5. 8	14. 3
22/09/80	9	4. 09	201. 28	0. 439	0. 525	43. 82	2. 46	1560	7. 6	6. 9	16. 5	0. 0	4. 7	4. 8	15. 0	0. 1	0. 0	4. 5	5. 8	14. 3
01/10/80	3					33. 12			7. 5				5. 1	4. 8	12. 7	0. 2	0. 0	5. 1	6. 3	11. 4
04/10/80	23	3. 33	153. 25	0. 539	0. 465	29. 55	2. 18	1440	7. 4	5. 2	13. 0	0. 0	5. 3	4. 8	11. 6	0. 2	0. 0	5. 4	6. 6	9. 9
27/10/80	5	3. 77	181. 06	0. 403	0. 418	31. 39	2. 09	1380	7. 8	5. 5	14. 2	0. 0	5. 3	3. 8	11. 8	0. 1	0. 0	6. 7	3. 0	11. 3
01/11/80	10					32. 72			7. 8				5. 3	4. 5	11. 8	0. 1	0. 0	7. 0	3. 1	11. 6
11/11/80	13	3. 87	187. 38	0. 308	0. 360	35. 37*	2. 28	1510	7. 9	5. 0	13. 3	0. 0	5. 4	5. 7	11. 7	0. 2	0. 0	7. 6	3. 4	12. 0
24/11/80	7	3. 93	191. 17	0. 345	-	28. 28	2. 73		7. 5				6. 8	2. 3	15. 7*	0. 2	0. 0	4. 6	0. 4*	20. 0
01/12/80	6					28. 13			7. 4				6. 3	6. 0	14. 3	0. 2	0. 0	4. 3	6. 5	16. 0
07/12/80	18	3. 80	182. 95	0. 312	0. 369	28. 00	2. 73	1780	7. 3	4. 7	11. 9	0. 0	5. 8	9. 2	13. 0	0. 2	0. 0	4. 0	11. 7	12. 5
25/12/80	7	3. 88	188. 01	0. 398	0. 359	42. 10*	2. 18	1490	8. 2	5. 6	13. 4	0. 0	3. 9	5. 6	12. 3	0. 2	0. 0	4. 2	6. 9*	10. 9*
01/01/81	6					43. 24			7. 7				2. 7	7. 7	11. 1	0. 3	0. 0	4. 3	8. 6	8. 9
07/01/81		4. 20	208. 23	0. 425	0. 512	44. 21	2. 18	1410	7. 5	4. 3	10. 5	0. 0	1. 8.	9. 5	10. 2	0. 3	0. 0	4. 3	10. 2	7. 3

* corrected or estimated data

6. 5. EH 13, calculation sheet after data checking and interpolation

Observation year : 1980
Catchment area : Bahr Hadus drain
Measurement point : EH 13
Remarks : Data on discharges of 1979, 1981 and 1982 are also used

Waterdepth : D = 2.86 - Hm
Pendulum constant : c_p = Q = 2.47 $\bar{v}_p$
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) ^.....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q** (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RCS	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
07/12/80	1				0.139	34.33														
08/12/79	17					35.47	2.13	1400	7.6	5.7	13.7	0.0	4.4	4.6	12.0	0.2	0.0	4.8	7.9	8.5
25/12/80	7				0.222	54.83														
01/01/80	6					44.99			8.1				3.9							
07/01/80	21				0.148	36.56	2.24	1430	8.2	6.8	15.5	0.0	4.8	3.1	11.1	0.2	0.0	3.3	4.8	10.2
28/01/80	4					12.20	4.33	2690	7.6	11.7	29.1	0.0	9.0	3.6	13.9	0.2	0.0	3.8	5.2	13.5
01/02/80	10	2.19				7.56			7.2				19.8	4.1	30.0	0.1	0.0	4.9	8.7	29.6
11/02/80	12					22.65	5.78	3520	7.4	11.1	29.4	0.0	11.0	13.6	65.6	0.3	0.0	10.2	20.1	69.0
23/02/81	3	2.29				40.75								10.4	36.2	0.2	0.0	5.3	11.7	40.8
26/02/80	4					42.16	2.21	1400	7.3	5.0	11.7	0.0	5.0	5.5	11.4	0.2	0.0	3.6	7.0	11.5
01/03/80	9					44.04			7.3				4.9	6.1	10.3	0.2	0.0	3.6	6.6	11.3
10/03/80	14					48.26	2.04	1270	7.3	3.3	8.1	0.0	4.7	7.3	8.2	0.2	0.0	3.6	5.8	11.0
24/03/80	8					51.56	2.64	1710	7.2*	6.1	16.4	0.0	6.3	5.3	14.6	0.2	0.0	8.0	2.7	15.7
01/04/80	9					53.45			7.2				5.7	5.5	13.8	0.2	0.0	5.1	4.2	15.9
10/04/79	4					55.57														
14/04/80	7					55.34	2.47	1440	7.2	5.6	8.6	0.0	5.0	5.9	13.0	0.2	0.0	0.8	6.8	16.5
21/04/80	10					54.94	2.13	1380	7.5	6.5	15.1	0.0	4.0	4.1	13.0	0.1	0.0	4.4	6.3	10.5
01/05/80	4					54.37			7.4				4.1	5.0	13.1	0.2	0.0	2.9	7.8	11.7
05/05/80	14					54.14	2.29	1490	7.4	6.1	12.6	0.0	4.2	5.3	13.2	0.2	0.0	2.3	8.4*	12.2*
19/05/79	8					53.34														
27/05/80	5					51.21	2.16	1390	7.6	6.3	14.8	0.0	5.0	3.6	13.0	0.0	0.0	4.4	5.2	12.0
01/06/80	3					49.88			7.6				5.7	5.1	12.4	0.2	0.0	3.0	6.6	13.8
04/06/80	12					49.08	2.46	1510	7.6	4.8	10.4	0.0	6.2	6.1	12.0	0.3	0.0	2.2	7.4	15.0
16/06/80	3					45.89	2.33	1460	7.1	6.2	15.4	0.0	5.0	4.5	13.6	0.2	0.0	5.2	5.6*	12.5*
19/06/79	12					45.09														
01/07/80	13					46.91	2.73	1660	7.1	6.8	16.9	0.0	6.0	4.5	15.6	0.2	0.0	5.2	4.6	16.5
14/07/79	2					48.89														
16/07/80	16					49.33	2.73	1780	7.3	9.2	21.8	0.0	3.6	4.9	19.0	0.2	0.0	4.8	7.7	15.2
01/08/80	5					52.84	2.82	1800	7.7	6.9	17.4	0.0	6.3	5.2	16.5	0.2	0.0	5.4	6.9	15.9
06/08/80	12	2.32			0.218	53.94														
18/08/80	14	2.31			0.190	46.93	2.73	1750	7.4	6.6	16.6	0.0	5.2	5.6	15.3	1.1	0.0	5.4	6.2	15.6
01/09/80	21					46.63			7.4				5.4	5.7	15.5	0.7	0.0	5.3	6.2	15.8
22/09/80	9				0.187	46.19	2.73	1730	7.5	6.5	16.5	0.0	5.7	5.8	15.7	0.1	0.0	5.2	6.0	16.1
01/10/80	3					55.82			7.3				3.7	3.4	17.0	1.0	0.0	6.0	4.0	15.1
04/10/80	23				0.239	59.03	2.46	1620	7.3	10.0	23.6	0.2	3.2	2.8	17.4	1.2	0.0	6.2	3.6	14.8
27/10/80	5				0.255	62.99	2.18	1420	8.0	5.3	13.8	0.0	5.0	5.0	11.9	0.1	0.0	6.6	2.7	12.7
01/11/80	10					57.31			7.9				5.0	5.3	12.4	0.1	0.0	6.9	2.5	13.4
11/11/80	4				0.186	45.94	2.46	1600	7.8	5.8	15.5	0.0	5.1	6.0	13.7	0.2	0.0	7.6	2.1	15.3
15/11/81	9	2.32				46.17														
24/11/80	7				0.176	43.47	3.28	2150	7.4	7.5	18.5	0.0	8.0	4.8	18.9	1.1	0.0	4.5	7.9*	20.4*
01/12/80	6					38.55			7.4				6.9	5.5	18.8	0.8	0.0	4.6	9.9	17.5
07/12/80	18				0.139	34.33	3.19	2020	7.4	7.6	19.0	0.0	5.8	6.2	18.7	0.5	0.0	4.8	12.0	14.4
25/12/80	7				0.222	54.83	2.55	1780	8.1	9.1	21.7	0.0	3.9	3.7	17.8	0.1	0.0	5.4	5.9*	14.2*
01/01/81	6					44.99			8.1				3.6	3.4	15.9	0.1	0.0	5.0	4.4	13.6
07/01/81					0.148	36.56	2.37*	1250	8.2*	7.6	17.0	0.0	3.2*	3.0*	13.4*	0.1*	0.0	4.4*	2.5*	12.8*

* corrected or estimated data

6. 6. MG 09, calculation sheet after data checking and interpolation

Observation year : 1980
Catchment area : Gharbia drain
Measurement point : MG 09
Remarks : Waterquality data jan-march from observation year 1981

Waterdepth : D = ... - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) ^.....

Date	P	D (ΔH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						8.86	2.28	1530	7.5	9.4	21.1	0.0	4.4	1.8	16.5	0.2	0.0	4.7	8.3	9.9
01/01/80																				
23/01/81						8.23	2.09	1390	8.0	4.2	10.3	0.0	4.8	6.3	10.0	0.4	0.0	4.0	8.2	9.3
01/02/80																				
09/02/81						6.26	6.44	3930	7.2	9.4	28.0	0.0	14.2	14.2	35.4	1.2	0.0	9.8	4.0	51.3
22/02/81						6.26	2.32	1440	7.0	4.1	10.1	0.0	6.5	6.1	10.3	0.5	0.0	4.0	3.7	15.7
01/03/80																				
06/03/81						9.97	1.81	1190	7.6	5.3	12.0	0.0	6.5	0.6	10.0	0.9	0.0	4.0	3.8	10.2
21/03/81	11					9.97	2.26	1370	7.6	6.2	14.2	0.0	3.8	5.3	13.3	0.2	0.0	3.5	2.2	16.9
01/04/80	15					10.30			7.5				3.6	4.1	10.9	0.2	0.0	3.6	1.8	13.4
04/04/81						10.62	1.36	930	8.2	4.2	9.0	0.0	3.1	3.0	7.3	0.2	0.0	3.3	3.5*	6.8*
16/04/80	15					10.62	1.42	920	7.4	4.5	10.0	0.0	3.5	2.7	8.0	0.2	0.0	3.8	1.6	9.0
01/05/80	5					9.95			7.7				3.9	3.7	10.7	0.2	0.0	3.5	3.4	11.6
06/05/80	14					9.28	2.13	1320	7.8	6.0	13.5	0.0	4.2	4.3	12.3	0.2	0.0	3.6	4.2	13.2
20/05/80	12					9.28	1.38	910	7.4	2.8	6.3	0.0	3.5	3.7	5.3	1.5	0.0	3.6	2.2	8.2
01/06/80	8					10.96			7.5				2.6	2.9	6.0	0.6	0.0	4.0	1.1	7.0
09/06/80	13					12.63	1.25*	710	7.6	4.1	8.7	0.0	2.1	2.4	6.1	0.2	0.0	4.0	0.7	6.1
22/06/80	9					12.63	1.92	1290	7.7	6.0	14.1	0.0	2.8	4.7	11.6	0.4	0.0	4.8	6.4	8.3
01/07/80	7					14.08			7.6				2.7	4.7	9.2	0.3	0.0	4.8	3.4	8.7
08/07/80	17					15.53	1.48	960	7.6	4.0	9.3	0.0	2.6	4.6	7.5	0.2	0.0	4.7	1.5	8.7
25/07/80	7					15.53	1.43	960	8.0	4.8	11.2	0.0	3.2	2.8	8.4	0.1	0.0	5.0	1.7	7.8
01/08/80	6					16.69			7.5				4.1	2.2	7.3	0.1	0.0	5.0	1.2	7.5
07/08/80	23					17.84	1.27	870	7.3	3.6	8.5	0.0	4.7	1.8	6.5	0.1	0.0	5.0	0.9	7.2
30/08/80	2					17.84	1.53*	910	7.6	5.4	12.1	0.0	3.2	1.8	8.6	0.1	0.0	4.7	1.4	7.6
01/09/80	13					16.15			7.6				3.4	2.0	9.2	0.2	0.0	5.1	1.4	8.3
14/09/80	13					14.46	1.40	930	7.6	4.7	10.8	0.0	3.2	2.4	7.9	0.6	0.0	4.8	0.6	8.7
27/09/80	4					14.46	1.51	950	7.6	2.2	5.6	0.0	3.2	6.8	4.9	0.1	0.0	5.4	1.5	8.1
01/10/80	14					13.88			7.5				3.4	6.1	4.8	0.1	0.0	5.4	1.5	7.5
15/10/80	17					13.30	1.04	710	7.4	2.2	5.1	0.0	3.7	2.8	3.9	0.1	0.0	4.9	1.0	4.6
01/11/80	5					11.11			7.6				4.4	1.7	5.2	0.2	0.0	4.4	0.5	6.6
06/11/80	14					8.92	1.40	920	7.6	3.6	8.5	0.0	5.5	1.5	6.7	0.3	0.0	5.0	0.4	8.6
20/11/80	11					8.92	1.40	910	7.4	1.6	3.9	0.0	3.9	6.9	3.7	0.2	0.0	4.0	2.4	8.3
01/12/80	29					9.66			7.4				3.9	5.2	7.4	0.2	0.0	4.1	4.1	8.5
30/12/80	2					10.40	2.28	1530	7.5	9.4	21.1	0.0	4.4	1.8	16.5	0.2	0.0	4.7	8.3	9.9
01/01/81	22					9.63			7.5				4.7	2.3	17.1	0.2	0.0	5.0	8.8	10.5
23/01/81						8.86	2.09	1390	8.0	4.2	10.3	0.0	4.8	6.3	10.0	0.4	0.0	4.0	8.2	9.3

* corrected or estimated data

6.7. WE 10, calculation sheet after data checking and interpolation

Observation year : 1980
Catchment area : Edko drain
Measurement point : WE 10
Remarks : Water quality data of Jan - Febr. are from 1981

Waterdepth : D = _____ - Hm
Pendulum constant : c_p = _____
Float constant : c_D = _____ + _____ D
Calibration : Q = _____ (D _____)

Date	P	D (H) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}_p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						2.44*	6.37	4750	7.9	19.0	47.3	0.0	3.7	12.8	54.6	0.7	0.0	4.7	22.6*	44.5*
01/01/80																				
I/01/80						1.91														
20/01/81						2.45	7.55	5500	7.4	25.5	69.9	0.0	3.8	11.3	70.0	0.9	0.0	10.0	27.4	48.6
III/01/80						1.64														
01/02/80																				
03/02/81						2.18	13.29	9620	8.0	23.2	68.1	0.0	16.4	27.1	108.0	0.9	0.0	8.2	44.9*	99.3*
08/02/81						2.18	4.75-		7.0				6.5	20.8	28.0	0.7	0.0	7.3	16.4*	32.3
II/02/80						1.96														
25/02/81	5					1.86	6.43*		6.9				6.5	11.4	44.0	0.6	0.0	5.0	6.7	50.8
01/03/80	11					1.64			7.0				8.4	15.4	64.0	1.0	0.0	6.4	12.9	70.0
I/03/80						1.42														
12/03/80	12					2.60	7.82	4900	7.7	19.0	48.7	0.0	6.8	13.2	60.0	1.0	0.0	5.0	14.6	61.4
24/03/80	8					5.64	3.91	2540	7.2	13.1	35.1	0.0	4.5	5.5	29.4	0.8	0.0	9.6	8.4	30.2
01/04/80	8					5.03			7.3				4.5	7.6	34.1	0.8	0.0	7.6	6.9	32.5
09/04/80	13					4.42	4.93	3450	7.4	14.8	37.0	0.0	4.5	10.2	40.0	0.8	0.0	5.0	15.0	35.5
II/04/80						4.46														
22/04/80	9					4.62	4.67	2960	7.7	21.8	42.5	0.0	3.2	3.4	39.6	0.6	0.0	2.8	15.0	29.0
01/05/80	12					4.84			7.7				4.0	6.1	33.5	0.5	0.0	4.2	11.7	28.2
I/05/80						5.05														
13/05/80	8					5.47	3.83	2290	7.7	9.4	24.1	0.0	4.7	8.8	24.4	0.4	0.0	5.6	7.1*	25.6*
21/05/80	11					4.99	3.74	2280	6.7	9.2	23.7	0.0	7.1	6.4	24.0	0.2	0.0	5.6	1.9	30.2
01/06/80	3					5.67			7.2				4.7	9.0	19.7	1.6	0.0	5.3	5.8*	23.9*
04/06/80	10					6.35	3.15	1910	7.6	6.9	17.2	0.0	3.8	8.8	17.2	1.8	0.0	4.8	6.1*	20.7*
14/06/80	17					6.06	4.30	2580	7.9	10.1	24.4	0.0	3.0	11.7	27.5	1.1	0.0	3.7	6.2	33.4
III/06/80						6.81														
01/07/80	1					7.88			7.6				5.6	10.5	30.1	0.7	0.0	8.7	7.2	31.0
02/07/80	14					8.95	4.00	2630	7.6	10.1	27.5	0.0	5.1	9.3	27.0	0.6	0.0	8.0	6.4	27.6
16/07/80	16					8.84	3.55	2280	7.8	11.7	29.6	0.0	5.1	4.4	25.5	0.6	0.0	6.8	6.3	22.5
III/07/80						8.93														
01/08/80	1					9.18			7.7				4.8	5.4	24.9	0.2	0.0	6.7	4.2	24.4
02/08/80	16					9.42	3.45	2160	7.7	10.9	27.5	0.0	4.7	5.3	24.3	0.2	0.0	6.5	4.1	23.9
18/08/80	14					9.09	3.28	2080	7.6	9.9	24.9	0.0	3.7	6.9	22.2	0.6	0.0	6.1	6.4	20.4
III/08/80						8.94														
01/09/80	1					9.61			7.4				4.8	4.3	22.8	0.4	0.0	6.3	6.8	19.2
02/09/80	16					10.28	2.91	1950	7.4	10.4	25.4	0.0	4.6	3.9	21.4	0.4	0.0	5.9	6.5	17.9
18/09/80	9					10.29	3.28	2070	7.6	10.5	25.8	0.0	3.4	6.1	22.9	0.5	0.0	5.6	5.9	21.4
27/09/80	4					10.03	3.28	2110	7.7	7.8	20.8	0.0	4.7	8.3	20.0	0.4	0.0	6.8	6.3	20.3
01/10/80	12					8.56			7.6				5.0	8.7	21.5	0.4	0.0	7.3	5.9	22.4
I/10/80						7.09														
13/10/80	19					5.98	3.55	2200	7.5	8.8	23.8	0.0	4.7	8.3	22.5	0.2	0.0	7.8	1.6	26.3
III/10/80						5.22														
01/11/80	1					5.21			7.5				4.5	9.5	25.0	1.1	0.0	7.5	6.1	26.5
02/11/80	14					5.19	4.00	2510	7.5	9.4	25.5	0.0	4.2	9.5	25.0	1.1	0.0	7.4	6.3*	26.4*
16/11/80	15					6.24	4.55	2940	8.0	10.8	27.7	0.0	6.8	8.7	30.0	0.2	0.0	5.3	9.5	30.9
III/11/80						5.41														
01/12/80	2					5.16			7.5				4.5	7.4	35.8	1.0	0.0	4.8	14.8	29.1
03/12/80	14					4.91	5.00	3170	7.4	15.6	37.7	0.0	4.5	7.3	37.5	1.1	0.0	4.8	15.9*	29.4*
17/12/80	13					2.60*	6.55	4610	7.1	19.5	48.1	0.0	5.2	10.1	54.0	0.8	0.0	4.7	19.5*	45.9*
30/12/80	2					2.44*	6.37	4750	7.9	19.0	47.3	0.0	3.7	12.8	54.6	0.7	0.0	4.7	22.6*	44.5*
01/01/81	19					2.18			7.8				4.2	14.2	62.9	0.8	0.0	5.8	25.9	50.4
I/01/81						1.91														
20/01/81						2.45	7.55	5500	7.4	25.5	69.9	0.0	3.8	11.3	70.0	0.9	0.0	10.0	27.4	48.6

* corrected or estimated data

6. 8. WE 11, calculation sheet after data checking and interpolation

Observation year : 1980
Catchment area : Edko drain
Measurement point : WE 11
Remarks : Water quality data of Jan- Febr. are from observation year 1981

Waterdepth : D = ... - Hm
Pendulum constant : c_p = ...
Float constant : c_D = ... + ... D
Calibration : Q = ... (D .....) .....

Date	P	D (δH) (m)	A (m^2)	$\bar{v}$ (m/s)	$\bar{v}p$ (m/s)	Q (m^3/s)	EC	TDS (ppm)	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
30/12/80						4. 16	3. 37	2280	7. 6	11. 4	26. 8	0. 0	3. 2	6. 9	25. 6	0. 5	0. 0	4. 3	10. 7	21. 2
01/01/80																				
I/01/80						2. 01														
20/01/81						3. 09	28. 21	20560	7. 0	57. 8	166. 0	0. 0	11. 0	36. 0	280. 0	2. 7	0. 0	8. 5	116. 3	204. 9
III/01/80						1. 93														
01/02/80																				
03/02/81						2. 53	22. 75*	14830	7. 6	37. 2	112. 9	0. 0	20. 4	30. 6	188. 0	0. 9	0. 0	10. 8	73. 1	156. 0
08/02/81						2. 53	12. 56		7. 5				10. 4	16. 4	95. 0	3. 0	0. 0	6. 5	14. 3	104. 0
II/02/80						4. 17														
25/02/81	5					4. 78	3. 40*		7. 2				4. 6	6. 0	20. 0	0. 5	0. 0	4. 4	3. 4	23. 3
01/03/80	11					4. 74			7. 3				4. 8	5. 2	22. 2	0. 5	0. 0	4. 7	4. 2	24. 8
I/03/80						4. 69														
12/03/80	12					8. 23	2. 53*	1380	7. 7	8. 4	17. 4	0. 0	3. 0	3. 7	15. 3	0. 3	0. 0	3. 0	3. 5	15. 8
24/03/80	8					7. 75	2. 21	1460	7. 4	7. 7	19. 3	0. 1	3. 5	3. 6	14. 6	0. 5	0. 0	7. 2	1. 5	13. 5
01/04/80	8					7. 88			7. 4				3. 7	4. 5	15. 3	0. 5	0. 0	5. 6	3. 1	15. 3
09/04/80	13					8. 01	2. 55	1590	7. 4	7. 5	17. 4	0. 0	3. 8	5. 3	16. 0	0. 5	0. 0	4. 0	4. 6	17. 0
II/04/80						9. 78														
22/04/80	9					9. 78	1. 79	1160	7. 9	6. 3	13. 0	0. 0	3. 4	3. 1	11. 4	0. 2-	0. 0	2. 8	5. 3	10. 0
01/05/80	12					9. 70			7. 9				3. 6	3. 7	11. 2	0. 3	0. 0	3. 6	3. 9	11. 3
I/05/80						9. 61														
13/05/80	8					10. 27	1, 96	1170	7. 9	5. 1	12. 0	0. 0	3. 7	4. 3	10. 2	0. 4	0. 0	4. 4	2. 1	12. 1
21/05/80	11					6. 08	1. 87	1230	6. 7	4. 2	10. 6	0. 0	7. 4	2. 0	9. 2	0. 2	0. 0	5. 2	3. 5	10. 1
01/06/80	3					7. 57			7. 1				4. 6	3. 8	5. 9	0. 2	0. 0	5. 0	1. 9	7. 6
04/06/80	10					9. 06	1. 21	780	7. 4	2. 4	5. 7	0. 0	3. 5	3. 7	4. 6	0. 2	0. 0	4. 4	1. 4	6. 2
14/06/80	17					8. 87	2. 04	1280	7. 9	4. 0	9. 4	0. 0	5. 0	5. 7	9. 2	0. 5	0. 0	3. 6	5. 4	11. 4
III/06/80						11. 02														
01/07/80	1					10. 87			7. 6				4. 0	3. 5	10. 4	0. 4	0. 0	6. 5	0. 6	11. 2
02/07/80	14					10. 71	1. 87	1230	7. 6	5. 5	13. 8	0. 0	4. 1	3. 5	10. 7	0. 4	0. 0	6. 8	0. 4	11. 5
16/07/80	16					10. 96	1. 41	950	7. 6	4. 7	11. 1	0. 0	2. 0	3. 8	8. 0	0. 3	0. 0	5. 8	1. 4	6. 9
III/07/80						7. 47														
01/08/80	1					7. 38			7. 2				3. 1	3. 5	9. 7	0. 2	0. 0	5. 5	1. 7	9. 3
02/08/80	16					7. 28	1. 65	1080	7. 2	5. 3	12. 7	0. 0	3. 2	3. 4	9. 7	0. 2	0. 0	5. 4	1. 7	9. 4
18/08/80	14					11. 45	1. 57	1040	7. 3	4. 9	11. 6	0. 0	3. 7	2. 8	8. 8	0. 4	0. 0	5. 3	1. 7	8. 7
III/08/80						11. 38														
01/09/80	1					11. 49			7. 4				3. 7	3. 8	7. 7	0. 4	0. 0	5. 9	1. 0	8. 7
02/09/80	16					11. 60	1. 53	1010	7. 4	3. 9	9. 6	0. 0	3. 7	3. 8	7. 5	0. 4	0. 0	5. 9	0. 8	8. 7
18/09/80	9					11. 10	1. 82	1210	7. 8	6. 0	14. 5	0. 0	5. 7	1. 1	11. 0	0. 4	0. 0	6. 0	1. 5	10. 7
27/09/80	4					9. 18	2. 00	1290	7. 3	5. 4	13. 3	0. 0	4. 2	4. 3	11. 2	0. 3	0. 0	5. 2	3. 5	11. 3
01/10/80	12					10. 03			7. 5				3. 5	3. 5	9. 1	0. 2	0. 0	4. 2	2. 6	9. 5
I/10/80						10. 87														
13/10/80	19					5. 61	1. 82	1150	8. 4	5. 0	12. 0	0. 0	4. 2	3. 8	10. 0	0. 2	0. 0	4. 8	1. 2	12. 2
III/10/80						5. 25														
01/11/80	1					4. 44			7. 3				3. 1	2. 8	7. 9	0. 3	0. 0	5. 1	1. 3	7. 7
02/11/80	14					3. 63	1. 67	1110	7. 2	5. 0	12. 2	0. 0	3. 7	3. 3	9. 3	0. 4	0. 0	6. 2	1. 6*	8. 9*
16/11/80	15					4. 55	2. 18	1450	7. 8	5. 5	13. 3	0. 0	4. 0	5. 5	12. 0	0. 5	0. 0	4. 6	5. 0*	12. 4*
III/11/80						5. 15														
01/12/80	2					5. 10			7. 5				3. 2	4. 0	12. 4	0. 4	0. 0	4. 3	4. 5*	11. 2*
03/12/80	14					5. 05	2. 00	1350	7. 5	6. 7	15. 5	0. 0	3. 2	3. 9	12. 7	0. 4	0. 0	4. 4	4. 5*	11. 3*
17/12/80	13					4. 46	3. 64	2340	7. 1	11. 1	28. 1	0. 0	4. 8	6. 2	26. 0	0. 5	0. 0	6. 2	5. 3	26. 0
30/12/80	2					4. 16	3. 37	2280	7. 6	11. 4	26. 8	0. 0	3. 2	6. 9	25. 6	0. 5	0. 0	4. 3	10. 7	21. 2
01/01/81	19					3. 09			7. 5				3. 8	9. 0	44. 0	0. 7	0. 0	4. 6	18. 4	34. 5
I/01/81						2. 01														
20/01/81						3. 09	28. 21	20560	7. 0	57. 8	166. 0	0. 0	11. 0	36. 0	280. 0	2. 7	0. 0	8. 5	116. 3	204. 9

* corrected or estimated data

ANNEX 7: DATA PRESENTATION

7.1. FB 03, Batts drain at Furgus

7.2. FB 04, Roda drain

7.3. EB 07, Bahr Baqar drain at 'Kubri Saud'

7.4. EH 11, Bahr Hadus drain at 'Kubri Bahr Hadus'

7.5. EH 13, Bahr Hadus drain at 'Outfall'

7.6. MG 09, Pump station no. 4

7.7. WE 10, Edko pump station

7.8. WE 11, Bosseili pump station

- detailed data presentation
- monthly averages
- empirical relationships

7.1. FB 03, Batts drain at Furgus: data presentation

7.1.1. FB 03, detailed data presentation

Date	Depth (m)	Discharge ($m^3.sec^{-1}$)	EC (mmho.cm^{-1})	TDS (ppm)	pH	SAR	adj. SAR	RSC (meq.l^{-1})	Ca (meq.l^{-1})	Mg (meq.l^{-1})	Na (meq.l^{-1})	K (meq.l^{-1})	CO_3 (meq-l^{-1})	HCO_3 (meq.l^{-1})	SO_4 meq.l^{-1})	Cl (meq.l^{-1})
09/01	1.58	3.80	1.45	940	8.3	2.7	6.4	0.0	3.6	5.3	5.6	0.1	0.0	4.2	3.4	7.0
23/01	0.51	0.54	4.83*	3290	7.4	12.1	31.3	0.0	6.6	10.1	35.0	0.7	0.0	5.3	17.0	30.1
06/02	0.46	0.57	4.17	3140	7.4	8.8	25.3	0.0	8.5	11.7	28.0	0.7	0.0	8.8	16.1	24.0
24/02	1.69	4.25	1.09*	640	7.6	3.7	7.5	0.0	2.6	1.4	5.2	0.4	0.0	3.5	0.8	5.3
14/03	1.16	2.79	1.43	950	7.8	3.3	8.1	0.0	4.5	3.1	6.5	0.1	0.0	5.2	2.8	6.2
04/04	1.08	2.55*	1.28	870	7.5	4.5	9.6	0.0	4.0	1.2	7.3	0.3	0.0	3.5	3.9	5.4
18/04	1.08	2.71	1.45	990	7.4	4.9	10.9	0.0	3.0	3.2	8.6	0.2	0.0	4.0	4.0	7.0
30/04	1.11	2.58*	1.22	810	7.6	4.4	9.6	0.0	2.6	2.4	7.0	0.2	0.0	4.0	2.2	6.0
18/05	1.03	2.40*	1.51	1000	8.0	5.3	11.7	0.0	3.0	2.7	9.0	0.3	0.0	4.0	4.4	6.6
02/06	0.85	1.56*	1.24	840	7.8	4.3	9.8	0.0	3.8	1.4	7.0	0.2	0.0	4.8	1.0	6.6
28/06	0.94	1.71*	1.33	900	7.3	3.8	8.7	0.0	4.5	1.8	6.7	0.3	0.0	4.4	3.3	5.6
11/07	0.86	1.82	1.78	1260	7.7	7.9	17.1	0.0	3.6	1.8	13.0	0.2	0.0	4.1	7.6	6.9
25/07	1.02	2.17	1.35*	890	7.5	4.7	8.8	0.0	3.3	2.4	7.8	0.2	0.0	2.1	5.8	5.7
17/09	1.38	3.42	1.31	910	7.6	4.9	11.3	0.8	3.2	1.8	7.7	0.4	0.0	5.8	1.2	6.1
11/10	1.22	3.15*	1.66	1130	7.9	5.0	12.5	0.0	3.7	3.3	9.3	0.2	0.0	7.0	2.1	7.4
04/11	0.91	1.80	1.68	1180	7.9	5.3	13.4	0.0	3.7	3.3	10.0	0.2	0.0	7.0	2.8	7.4
09/11	1.12	2.17	1.58	1070	7.8	4.8	11.7	0.0	3.9	2.8	8.7	0.2	0.0	6.4	3.0	6.2
17/12	1.21	3.03	2.00	1300	7.3	5.9	13.0	0.0	4.2	3.8	11.7	0.4	0.2	3.4	6.8*	9.9*

* corrected or estimated data

Table A7-1. Discharge and water quality measurements FB 03, observation year 1980

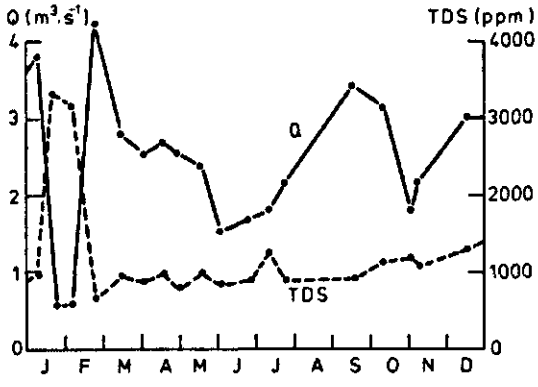


Fig. A 7-1. Discharge Q and salinity TDS of FB 03, observation year 1980

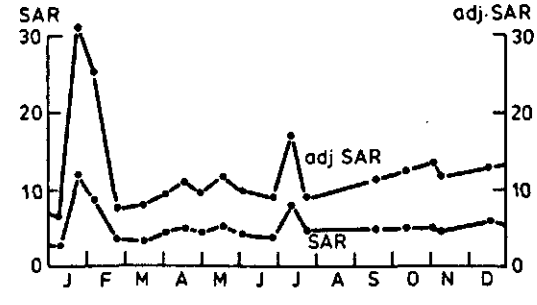


Fig. A 7-2. Sodium hazard, SAR and adj. SAR, of FB 03, observation year 1980

7.1.2. FB 03, data presentation: monthly averages

MONTH	Q m^3/sec	EC	TDS	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
January	2.10	1.90	1240	8.0	4.3	10.4	0.0	4.0	5.7	9.4	0.2	0.0	4.6	4.9	9.8
February	2.43	1.44	940	7.6	4.6	10.2	0.0	3.3	2.6	7.9	0.4	0.0	4.1	2.6	7.5
March	2.94	1.25	830	7.7	3.8	8.6	0.0	3.5	2.3	6.4	0.2	0.0	4.5	2.1	5.8
April	2.63	1.36	900	7.5	4.7	10.2	0.0	3.2	2.4	7.8	0.2	0.0	3.9	3.4	6.3
May	2.27	1.38	920	7.8	4.9	10.8	0.0	3.0	2.4	8.1	0.3	0.0	4.1	3.3	6.4
June	1.64	1.30	880	7.5	4.1	9.2	0.0	4.2	1.6	6.9	0.3	0.0	4.6	2.3	6.1
July	1.98	1.52	1030	7.5	5.8	12.0	0.0	3.5	2.1	9.7	0.2	0.0	3.2	6.1	6.2
August	2.69	1.33	890	7.6	4.7	10.3	0.0	3.2	2.1	7.7	0.3	0.0	4.0	3.4	5.9
September	3.28	1.36	940	7.6	4.9	11.3	0.5	3.3	2.0	7.9	0.4	0.0	5.8	1.6	6.2
October	2.77	1.61	1120	7.9	5.0	12.5	0.0	3.7	3.2	9.3	0.2	0.0	6.9	2.2	7.3
November	2.29	1.66	1150	7.6	5.1	12.4	0.0	4.0	3.2	9.7	0.2	0.0	5.6	4.1	7.4
December	2.93	1.98	1310	7.3	5.7	13.1	0.0	4.2	4.0	11.6	0.4	0.0	3.8	6.3	10.1
AVERAGE	2.50	1.51	1010	7.6	4.8	10.9	0.0	3.6	2.8	8.5	0.3	0.0	4.6	3.5	7.1

Table A 7-2. Average monthly discharge and water quality data FB 03, observation year 1980

7. 1. 3. FB 03, presentation of empirical relationships

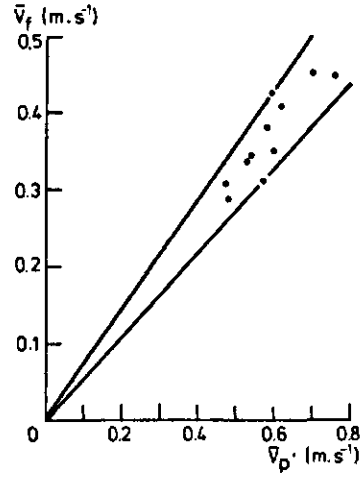


Fig. A 7-3. Float-pendulum relation FB 03, observation year 1980

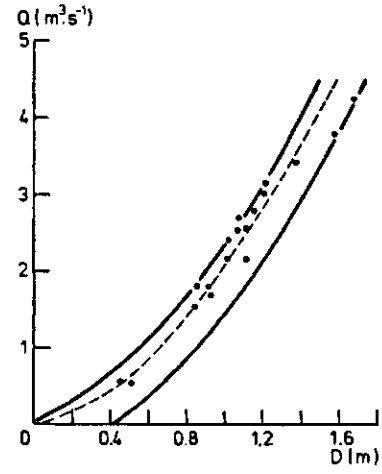


Fig. A 7-4. Discharge - depth relation FB 03, observation year 1980

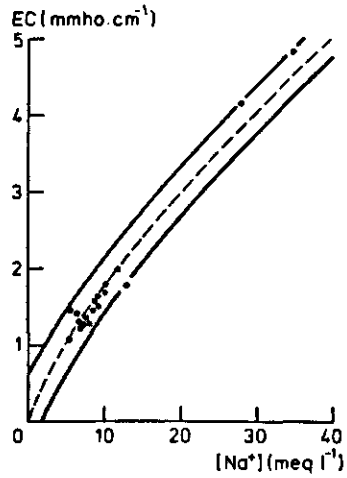


Fig. A 7-5. EC - Na concentration relation FB 03, observation year 1980

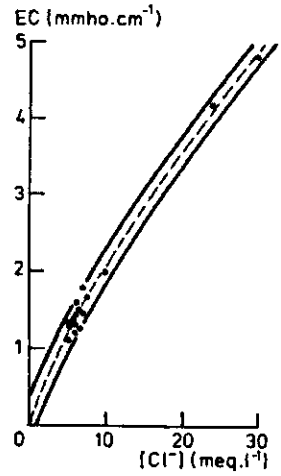


Fig. A 7-6. EC - Cl concentration relation FB 03, observation year 1980

7. 2. FB 04, Roda drain: data presentation

7. 2. 1. FB 04, detailed date presentation

Date	Depth (m)	Discharge ($m^3.sec^{-1}$)	EC (mmho.cm^{-1})	TDS (ppm)	pH	SAR	adj. SAR	RSC (meq.l^{-1})	Ca (meq.l^{-1})	Mg (meq.l^{-1})	Na (meq.l^{-1})	K (meq.l^{-1})	CO_3 (meq.l^{-1})	HCO_3 (meq.l^{-1})	SO_4 meq.l^{-1})	Cl (meq.l^{-1})
09/01	0. 75	4. 31*	2. 47	1590	8. 4	5. 4	13. 5	0. 0	5. 4	6. 1	13. 0	0. 2	0. 0	4. 7	8. 7	11. 3
23/01	0. 21	0. 12	8. 42	5990	7. 4	16. 8	49. 3	0. 0	6. 8	23. 1	65. 0	0. 7	0. 0	9. 3	33. 2	53. 1
06/02	0. 18	0. 15	8. 25	6160	7. 6	18. 2	49. 6	0. 0	14. 8	13. 4	68. 5	0. 6	0. 0	5. 8	40. 1	51. 4
24/02	0. 87	4. 79	1. 87	1250	7. 6	4. 9	11. 7	0. 0	5. 2	3. 3	10. 2	0. 4	0. 0	4. 4	5. 6	9. 1
14/03	0. 64	3. 07	2. 13	1650	7. 9	5. 2	13. 9	0. 0	5. 0	6. 9	12. 7*	0. 2	0. 0	7. 2	8. 5*	9. 1
04/04	0. 64	2. 69	1. 87	1240	7. 5	4. 9	11. 6	0. 0	5. 0	3. 2	10. 0	0. 4	0. 0	4. 2	7. 2	7. 2
18/04	0. 70	3. 71	1. 42	950	7. 4	4. 9	10. 8	0. 0	3. 0	2. 7	8. 3	0. 2	0. 0	4. 6	4. 2*	6. 0*
30/04	0. 71	2. 77	1. 44	970	7. 6	6. 5	13. 7	0. 0	2. 6	1. 9	9. 8	0. 2	0. 0	4. 0	3. 3	7. 2
18/05	0. 65	2. 47	1. 48	1000	7. 9	5. 2	12. 0	0. 0	3. 0	2. 7	8. 8	0. 2	0. 0	5. 2	3. 2*	6. 3*
02/06	0. 35	0. 93	2. 38	1570	7. 9	7. 0	17. 2	0. 0	5. 4	3. 4	14. 6	0. 3	0. 0	5. 6	7. 5	10. 6
28/06	0. 40	0. 95	2. 72	1770	7. 4	8. 2	19. 8	0. 0	4. 7	4. 5	17. 6	0. 4	0. 0	5. 0	9. 0	13. 2
11/07	0. 42	1. 16*	2. 81	1820	7. 4	10. 5	23. 9	0. 0	4. 2	3. 0	20. 0	0. 4	0. 0	4. 5	10. 2	12. 9
25/07	0. 55	1. 67	2. 73	1650	7. 4	7. 6	18. 0	0. 0	4. 7	4. 3	16. 2	0. 2	0. 0	4. 4	8. 5	12. 5
17/09	1. 15	3. 61	2. 28	1520	7. 7	8. 2	19. 0	0. 0	4. 2	2. 8	15. 4	0. 4	0. 0	4. 8	8. 3	9. 7
11/10	1. 10	3. 98	2. 18	1490	8. 0	6. 2	15. 8	0. 0	5. 8	3. 0	13. 0	0. 2	0. 0	6. 7	6. 2	9. 1
04/11	0. 96	2. 17*	2. 22	1520	8. 0	6. 4	16. 4	0. 0	5. 8	3. 0	13. 5	0. 2	0. 0	6. 7	6. 7	9. 1
09/11	0. 95	3. 52	2. 27	1530	7. 9	6. 3	15. 9	0. 0	5. 5	3. 5	13. 3	0. 4	0. 0	6. 4	7. 2	9. 1
17/12	1. 13	4. 01	2. 18	1450	7. 2	8. 3	18. 2	0. 0	3. 2	3. 4	15. 0	0. 4	0. 0	4. 6	7. 9*	10. 1*

* corrected or estimated data

Table A 7-3. Discharge and water quality measurements FB 04, observation year 1980

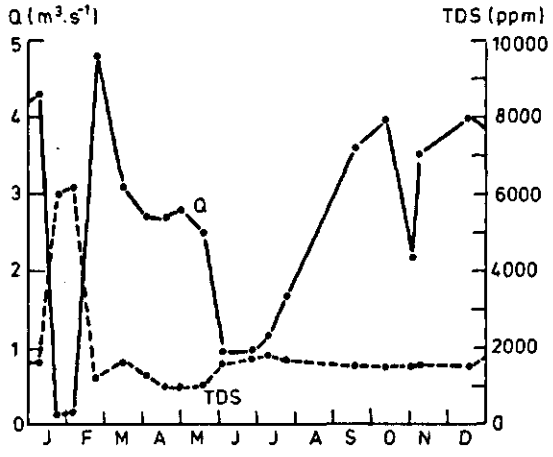


Fig. A 7-7. Discharge and salinity TDS of FB 04, observation year 1980

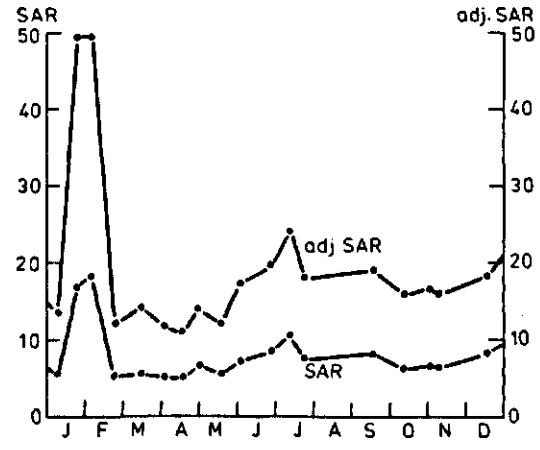


Fig. A 7-8. Sodium hazard, SAR and adj. SAR of FB 04, observation year 1980

7. 2. 2. FB 04, data presentation: monthly averages

MONTH	Q m^3/sec	EC	TDS	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
January	2.14	2.50	1720	8.0	6.1	15.3	0.0	5.3	6.3	14.8	0.2	0.0	4.8	9.9	11.9
February	2.49	2.09	1410	7.6	5.6	13.5	0.0	5.5	3.7	12.0	0.4	0.0	4.6	6.7	10.3
March	3.22	2.09	1490	7.7	5.1	13.0	0.0	5.1	5.4	11.6	0.3	0.0	6.0	7.7	8.7
April	2.72	1.54	1060	7.5	5.2	11.6	0.0	3.6	2.7	9.2	0.3	0.0	4.1	5.0	6.7
May	2.22	1.53	1040	7.8	5.8	13.2	0.0	3.1	2.5	9.7	0.2	0.0	4.9	3.6	7.0
June	0.94	2.44	1680	7.6	7.6	18.6	0.0	5.0	4.0	16.2	0.4	0.0	5.3	8.3	12.0
July	1.39	2.52	1710	7.4	8.6	20.2	0.0	4.5	3.8	17.6	0.3	0.0	4.5	9.1	12.6
August	2.48	2.28	1560	7.6	8.0	18.6	0.0	4.4	3.3	15.7	0.3	0.0	4.6	8.3	10.8
September	3.51	2.18	1520	7.7	7.8	18.4	0.0	4.5	2.9	15.0	0.4	0.0	5.1	8.0	9.7
October	3.42	2.10	1500	8.0	6.4	16.2	0.0	5.7	3.0	13.3	0.2	0.0	6.6	6.5	9.1
November	3.39	2.13	1510	7.6	6.7	16.5	0.0	5.0	3.4	13.7	0.4	0.0	5.8	7.4	9.3
December	3.92	2.24	1520	7.2	8.3	19.2	0.0	3.7	3.4	15.6	0.4	0.0	4.8	7.3	11.0
AVERAGE	2.65	2.10	1460	7.6	6.7	16.1	0.0	4.6	3.6	13.5	0.3	0.0	5.2	7.1	9.7

Table A 7-4. Average monthly discharge and water quality data FB 04, observation year 1980

7. 2. 3. FB 04, presentation of empirical relationships

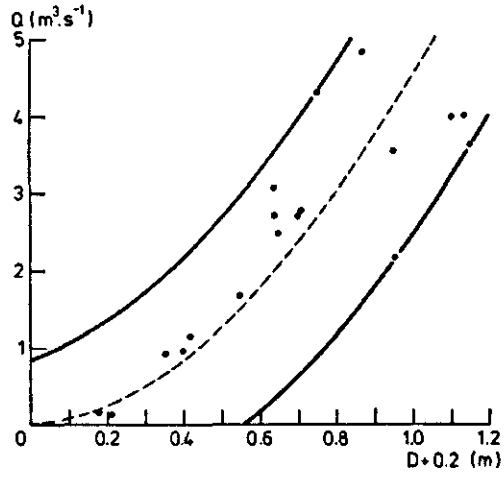


Fig. A 7-9. Discharge - depth relation FB 04, observation year 1980

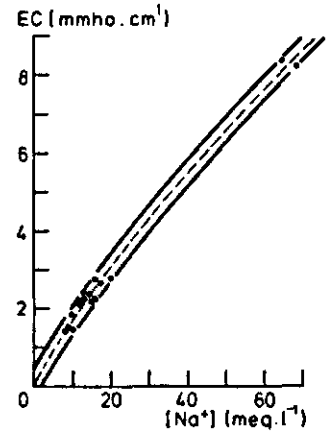


Fig. A 7-10. EC - Na concentration relation FB 04, observation year 1980

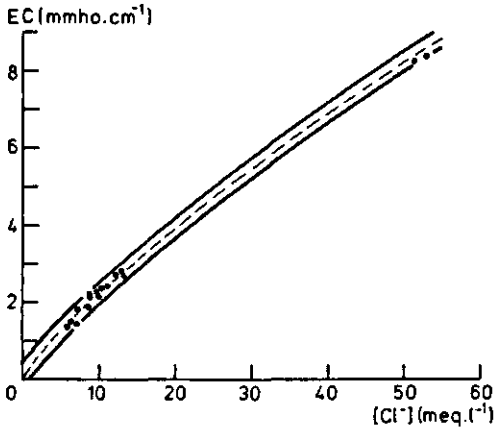


Fig. A 7-11. EC-Cl concentration relation FB 04, observation year 1980

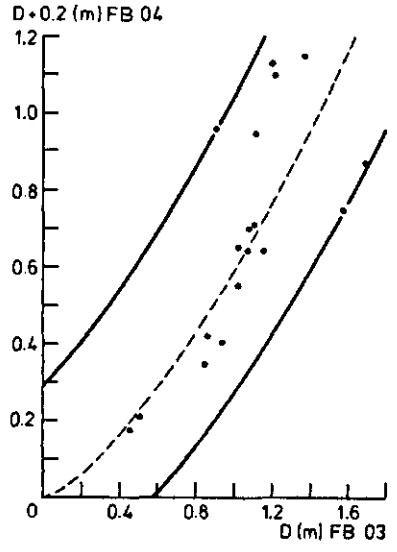


Fig. A 7-12. Depth - double mass relation, FB 04 and FB 03, observation year 1980

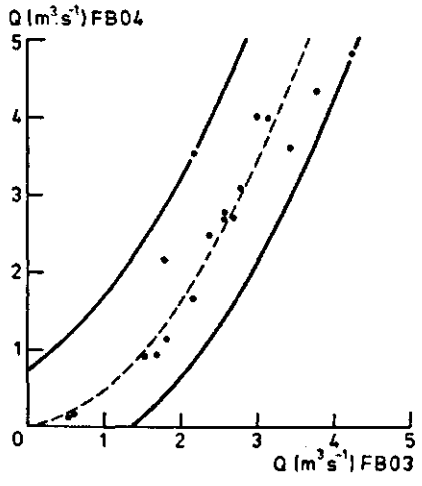


Fig. A 7-13. Discharge - double mass relation FB 04 and FB 03, observation year 1980

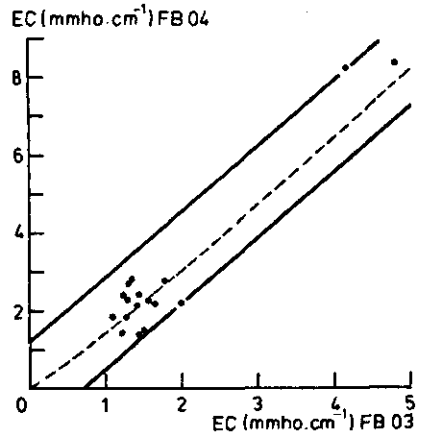


Fig. A 7-14. Salinity-double mass relation FB 04 and FB 03, observation year 1980

7.3. EB 07, Bahr Bagar drain at 'Kubri Saud': data presentation

7.3.1. EB 07, detailed data presentation

Date	Depth (m)	Discharge ($m^3.sec^{-1}$)	EC (mmho.cm^{-1})	TDS (ppm)	pH	SAR	adj. SAR	RSC (meq.l^{-1})	Ca (meq.l^{-1})	Mg (meq.l^{-1})	Na (meq.l^{-1})	K (meq.l^{-1})	CO_3 (meq.l^{-1})	HCO_3 (meq.l^{-1})	SO_4 meq.l^{-1})	Cl (meq.l^{-1})
06/01	3.04	28.82	1.18	820	7.2	3.1	7.3	0.0	3.6	2.4	5.4	0.3	0.0	5.1	2.8	3.8
27/01	2.92	28.40	1.46	1010	7.6	3.0	7.6	0.0	4.6	3.8	6.1	0.1	0.0	7.7	0.8	6.1
10/02	2.74	18.00	1.45	970	7.6	2.9	7.4	0.0	4.7	3.3	5.7	0.2	0.0	7.4	1.2	5.3
25/02	3.05	33.81	0.99*	650	7.8*	1.8	4.1	0.0	3.3*	2.8*	3.1*	0.1*	0.0	4.2*	2.7*	2.4*
09/03	2.96	30.59	1.17	780	7.7	0.5	1.4	0.0	5.2	5.2	1.2	0.2	0.0	5.2	2.3	4.3
23/03	2.91	26.27*	1.28*	1080	7.5	3.7	9.9	3.5	3.7	3.6	7.0	0.2	0.0	10.8	0.1	3.6
13/04	2.84	24.79	1.16	770	7.5	2.8	4.7	0.0	3.5	3.1	5.1	0.3	0.0	1.2	5.8	5.0
20/04	2.81	22.22*	1.12	800	7.3	3.3	7.9	0.7	3.0	2.7	5.5	0.1	0.0	6.4	0.9	4.0
04/05	2.81	20.98	1.22	820	7.2	3.9	8.3	0.0	3.2	2.4	6.6	0.1	0.0	3.2	4.1	5.0
26/05	2.88	23.13*	1.00	700	7.4	1.7	4.1	0.0	3.2	3.4	3.0	0.4	0.0	5.6	1.0	3.4
03/06	2.90	23.60	1.07	760	7.0	2.5	6.2	1.1	2.6	3.5	4.3	0.2	0.0	7.2	0.0	3.5
15/06	2.86	26.60	1.04	740	7.4	2.3	5.5	0.0	4.4	1.7	4.0	0.2	0.0	5.2	2.4*	2.7*
29/06	2.88	27.38	1.13	710	7.4	2.3	5.5	0.0	4.4	1.7	4.0	0.2	0.0	5.2	0.4	4.7
16/07	2.95	26.35	1.30*	820	7.3	5.7	11.7	0.1	2.2	1.8	8.0	0.2	0.0	4.1	1.8	6.3
31/07	3.08	31.67	1.04	720	8.1	2.7	6.3	0.0	3.4	2.3	4.5	0.2	0.0	5.4	0.8	4.2
18/08	3.01*	28.52*	1.02	720	8.6	2.3	5.5	0.0	3.2	2.9	4.0	0.2	0.0	5.3	1.4	3.6
22/09	3.22	33.52	1.06	750	7.4	3.0	7.0	0.0	3.2	2.4	5.0	0.2	0.0	5.4	1.3	4.1
04/10	3.18	35.40	1.13	830	7.3	2.4	6.0	0.4	3.7	2.3	4.2	1.2	0.0	6.4	1.4	3.6
27/10	3.09	24.05	1.15	760	7.3	1.6	3.9	0.0	4.2	3.3	3.1	0.6	0.0	5.0	0.9	5.3
11/11	3.04	35.07	1.16	860	7.8	2.4	6.2	0.0	4.6	2.7	4.6	0.2	0.0	7.0	0.8	4.3
24/11	3.10	26.23	1.66	1190	7.4	3.5	8.9	0.0	4.6	3.1	6.9	2.0	0.0	6.4	6.0	4.2
07/12	3.07	24.66	1.47	990	7.3	2.1	5.6	0.0	5.2	4.8	4.7	0.2	0.0	7.0	0.2*	7.7
25/12	3.32	39.40	1.40	970	7.9	4.4	10.5	0.0	3.2	3.0	7.7	0.1	0.0	5.8	3.7	4.5

* corrected or estimated data

Table A 7-5. Discharge and water quality measurements EB 07, observation year 1980

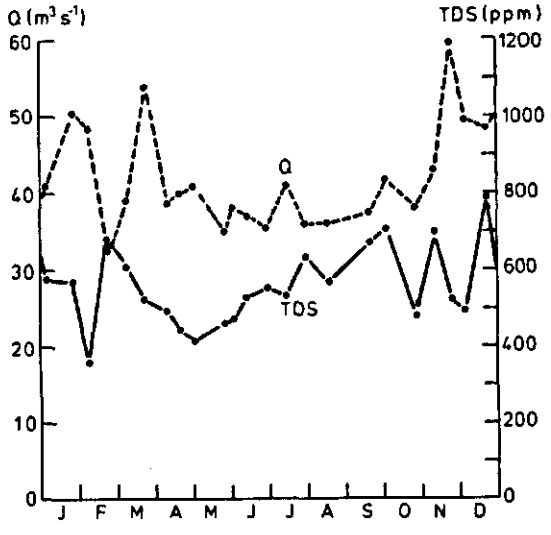


Fig. A 7-15. Discharge Q and salinity TDS of EB 07, observation year 1980

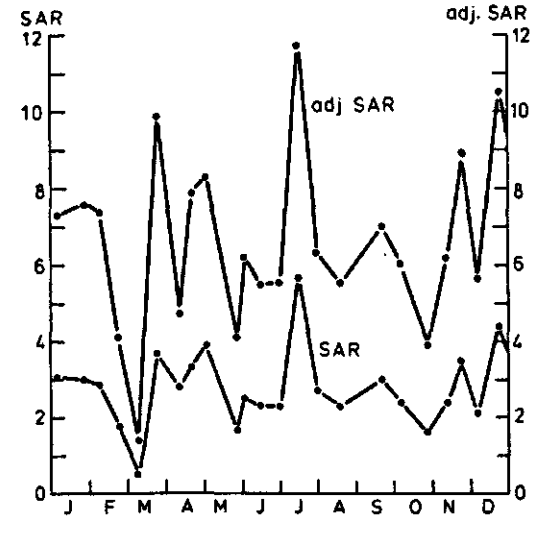


Fig. A 7-16. Sodium hazard, SAR and adj. SAR, of EB 07, observation year 1980

7.3.2. EB 07, data presentation: monthly averages

MONTH	Q m^3/sec	EC	TDS	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
January	28.63	1.26	900	7.4	3.0	7.6	0.0	4.1	3.0	5.7	0.2	0.0	6.4	1.7	4.9
February	25.75	1.11	800	7.7	2.2	5.5	0.0	4.0	3.2	4.2	0.1	0.0	5.7	2.0	3.8
March	28.52	1.20	890	7.6	1.9	5.1	0.0	4.3	4.2	4.0	0.2	0.0	7.2	1.6	3.9
April	23.54	1.19	830	7.4	3.2	7.4	0.0	3.3	3.0	5.7	0.2	0.0	4.3	3.4	4.5
May	22.21	1.08	750	7.3	2.6	6.1	0.0	3.1	3.0	4.6	0.3	0.0	4.7	2.2	4.1
June	26.03	1.01	740	7.3	2.3	5.7	0.0	4.0	2.1	4.1	0.2	0.0	5.7	1.2	3.5
July	28.03	1.13	760	7.5	3.9	8.7	0.0	3.0	1.9	6.1	0.2	0.0	4.7	1.2	5.3
Augustus	29.79	1.02	720	8.1	2.4	5.8	0.0	3.3	2.7	4.2	0.2	0.0	5.3	1.3	3.8
September	32.68	1.06	760	7.5	2.8	6.6	0.0	3.3	2.5	4.7	0.3	0.0	5.5	1.4	3.9
October	29.63	1.11	800	7.3	2.1	5.1	0.0	3.9	2.7	3.8	0.9	0.0	5.8	1.2	4.3
November	29.77	1.29	960	7.5	2.7	6.8	0.0	4.6	3.0	5.2	0.8	0.0	6.6	2.5	4.5
December	31.44	1.40	1000	7.5	3.4	8.5	0.0	3.9	3.7	6.6	0.3	0.0	6.3	2.7	5.5
AVERAGE	28.01	1.15	820	7.5	2.7	6.6	0.0	3.7	2.9	4.9	0.3	0.0	5.7	1.7	4.4

Table A 7-6. Average monthly discharge and water quality data EB 07, observation year 1980

7. 3. 3. EB 07, presentation of empirical relationships

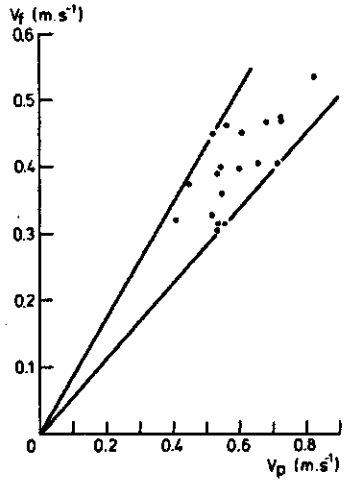


Fig. A 7-17. Float-pendulum relation EB 07, observation year 1980

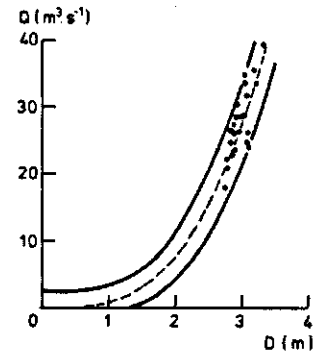


Fig. A 7-18. Discharge - depth relation EB 07, observation year 1980

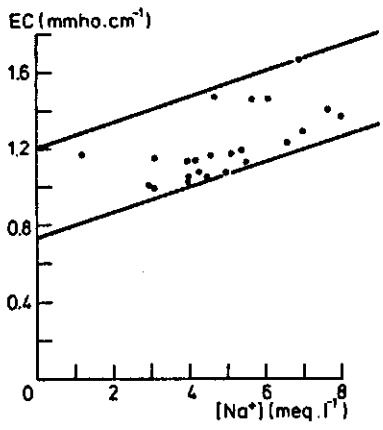


Fig. A 7-19. EC-Na concentration relation EB 07, observation year 1980

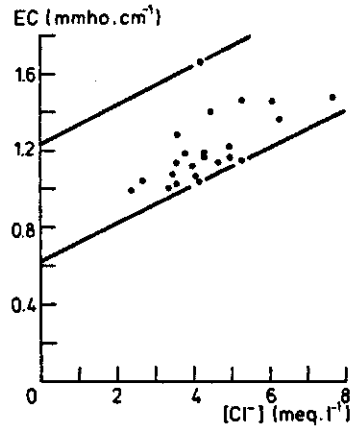


Fig. A 7-20. EC-Cl concentration relation EB 07, observation year 1980

7. 4. EH 11, Bahr Hadus drain at 'Kubri Bahr Hadus': data presentation

7. 4. 1. EH 11, detailed data presentation

Date	Depth (m)	Discharge ($m^3.sec^{-1}$)	EC (mmho.cm^{-1})	TDS (ppm)	pH	SAR	adj. SAR	RSC (meq.l^{-1})	Ca (meq.l^{-1})	Mg (meq.l^{-1})	Na (meq.l^{-1})	K (meq.l^{-1})	CO_3 (meq.l^{-1})	HCO_3 (meq.l^{-1})	SO_4 meq.l^{-1})	Cl (meq.l^{-1})
06/01	3.71	29.13	2.52	1550	7.4	5.8	14.0	0.0	4.2	7.0	13.7	0.2	0.0	4.2	4.9	16.0
27/01	3.46	21.03	3.83	2390	7.5	6.9	18.3	0.0	9.5	8.6	20.9	0.2	0.0	5.1	6.8	27.3
10/02	3.47	15.44	4.51	2740	7.6	8.0	21.7	0.0	8.9	10.8	25.0	0.2	0.0	6.2	7.5	31.2
25/02	3.85	32.43*	2.04*	1190	7.9*	4.9	10.5	0.0	3.8*	4.7*	10.2*	0.1*	0.0	2.6*	6.6*	9.6*
09/03	3.75	38.92	1.87	1360	7.7	3.7	8.8	0.0	5.2	6.8	9.0*	0.2	0.0	3.6	9.1*	8.5
23/03	3.57	29.47	2.31	1470	7.6*	4.7	12.7	0.0	5.2	6.4	11.2	0.2	0.0	8.0	0.2	14.8
13/04	3.72	35.12	2.21	1510	7.4	6.0	16.1	0.0	5.0	4.5	13.0	0.3	0.0	9.2	0.1	13.5
20/04	3.71	34.55	2.30	1430	7.7	6.1	14.6	0.0	4.5	4.5	13.0	0.2	0.0	4.4	6.3	11.5
04/05	3.60	30.09	2.50	1550	7.4	6.6	13.9	0.0	4.7	5.3	14.8	0.2	0.0	2.3	8.2	14.5
26/05	3.70	39.70	1.60	1080	7.6	4.3	10.0	0.0	5.0	2.6	8.3	0.1	0.0	4.4	5.6*	6.0*
03/06	3.62	24.69	2.22	1500	7.3	4.6	12.6	0.0	3.6	8.0	11.0	0.2	0.0	8.8	2.8	11.2
15/06	3.74	32.50*	2.38	1520	7.4	7.1	17.4	0.0	4.4	4.4	14.8	0.2	0.0	5.6	3.2	15.0
29/06	3.56	29.86*	2.55*	1470	7.4	8.5	20.1	0.0	3.4	3.4	15.7	0.4	0.0	5.6	2.3	15.0
16/07	3.88	40.78	2.55	1630	7.2	8.5	20.0	0.0	3.1	4.9	17.0	0.5	0.0	4.8	6.0	14.7
31/07	3.93	44.48	2.55	1620	7.8	7.1	17.6	0.0	4.7	4.8	15.5	0.2	0.0	5.4	5.8	14.0
18/08	3.90	34.30	2.55	1650	7.4	6.8	16.8	0.0	5.0	4.5	14.8	1.1	0.0	5.3	5.8	14.3
22/09	4.09	43.82	2.46	1560	7.6	6.9	16.5	0.0	4.7	4.8	15.0	0.1	0.0	4.5	5.8	14.3
04/10	3.33	29.55	2.18	1440	7.4	5.2	13.0	0.0	5.3	4.8	11.6	0.2	0.0	5.4	6.6	9.9
27/10	3.77	31.39	2.09	1380	7.8	5.5	14.2	0.0	5.3	3.8	11.8	0.1	0.0	6.7	3.0	11.3
11/11	3.87	35.37*	2.28	1510	7.9	5.0	13.3	0.0	5.4	5.7	11.7	0.2	0.0	7.6	3.4	12.0
24/11	3.93	28.28	2.73	1540	7.5	7.4	17.6	0.0	6.8	2.3	15.7*	0.2	0.0	4.6	0.4*	20.0
07/12	3.80	28.00	2.73	1780	7.3	4.7	11.9	0.0	5.8	9.2	13.0	0.2	0.0	4.0	11.7	12.5
25/12	3.88	42.10*	2.18	1410	8.2	5.6	13.4	0.0	3.9	5.6	12.3	0.2	0.0	4.2	6.9*	10.9

* corrected or estimated data

Table A 7-7. Discharge and water quality measurements EH 11, observation year 1980

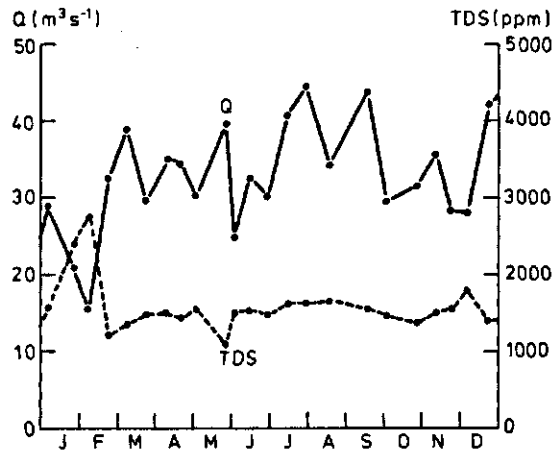


Fig. A 7-21. Discharge Q, and salinity, TDS of EH 11, observation year 1980

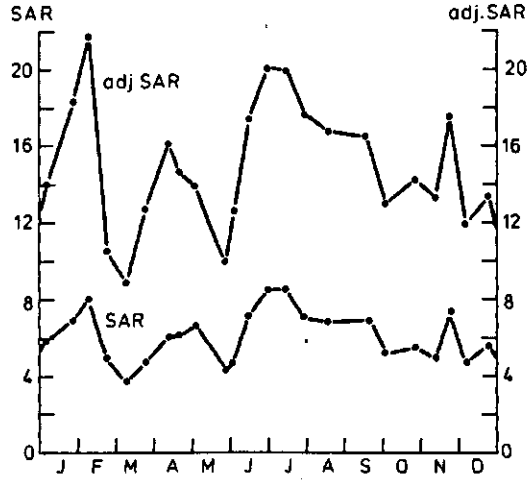


Fig. A 7-22. Sodium hazard, SAR and adj. SAR, of EH 11, observation year 1980

7. 4. 2. EH 11, data presentation: monthly averages

MONTH	Q m^3/sec	EC	TDS	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
January	25.22	3.07	1880	7.4	6.3	15.8	0.0	6.4	7.5	16.5	0.2	0.0	4.6	5.7	20.3
February	22.85	2.87	1790	7.7	6.2	15.1	0.0	6.0	7.1	15.8	0.1	0.0	4.0	7.1	17.9
March	33.88	2.13	1400	7.6	4.3	11.0	0.0	5.1	6.3	10.2	0.2	0.0	5.6	4.8	11.4
April	33.56	2.28	1480	7.5	5.9	15.2	0.0	4.8	4.8	13.0	0.2	0.0	6.5	3.2	13.1
May	34.32	1.94	1290	7.5	5.3	12.2	0.0	4.8	3.9	11.0	0.2	0.0	3.8	6.5	9.6
June	29.79	2.35	1500	7.4	6.8	17.0	0.0	3.9	4.9	14.2	0.3	0.0	6.3	2.9	14.1
July	39.45	2.49	1600	7.4	8.0	19.2	0.0	3.7	4.6	16.3	0.4	0.0	5.1	5.4	14.5
August	37.80	2.49	1620	7.5	6.9	16.9	0.0	4.9	4.6	15.0	0.7	0.0	5.2	5.8	14.2
September	40.22	2.42	1570	7.6	6.7	16.3	0.0	4.8	4.7	14.7	0.3	0.0	4.7	5.9	13.9
October	30.81	2.10	1410	7.6	5.4	13.7	0.0	5.3	4.3	11.8	0.1	0.0	6.1	4.6	10.8
November	31.79	2.40	1520	7.7	5.8	14.9	0.0	5.9	4.5	13.2	0.2	0.0	6.3	2.8	14.7
December	35.48	2.31	1540	7.6	5.2	12.7	0.0	4.5	7.0	12.5	0.2	0.0	4.2	8.5	11.5
AVERAGE	32.97	2.38	1530	7.5	6.1	15.0	0.0	4.9	5.2	13.6	0.3	0.0	5.2	5.2	13.6

Table A 7-8. Average monthly discharge and water quality data EH 11, observation year 1980

7. 4. 3. EH 11, presentation of empirical relationships

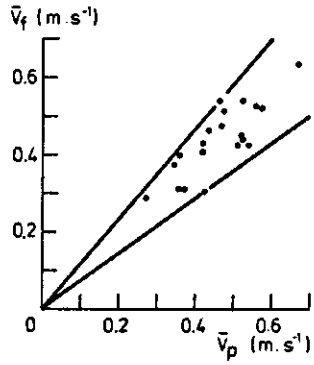


Fig. A 7-23. Float-pendulum relation EH 11, observation year 1980

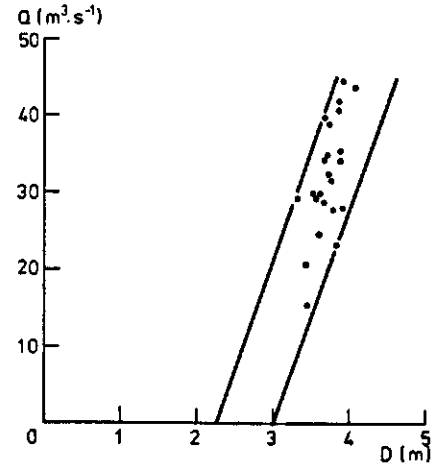


Fig. A 7-24. Discharge-depth relation EH 11, observation year 1980

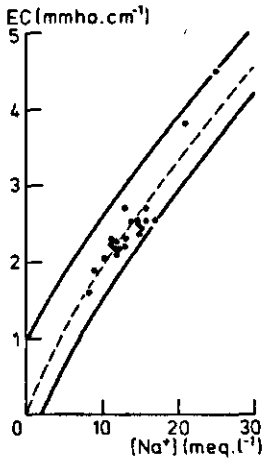


Fig. A 7-25. EC-Na concentration relation EH 11, observation year 1980

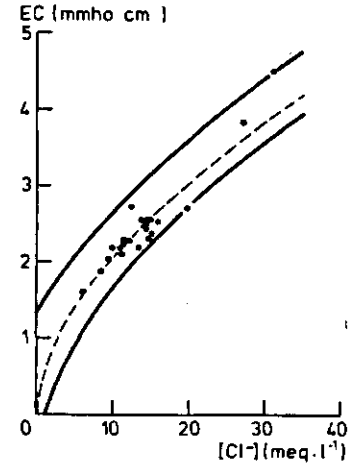


Fig. A 7-26. EC-Cl concentration relation EH 11, observation year 1980

7.5. EH 13, Bahr Hadus drain at 'Outfall': data presentation

7.5.1. EH 13, detailed data presentation

Date	Depth (m)	Discharge ($m^3.sec^{-1}$)	EC (mmho.cm^{-1})	TDS (ppm)	pH	SAR	adj. SAR	RSC (meq.l^{-1})	Ca (meq.l^{-1})	Mg (meq.l^{-1})	Na (meq.l^{-1})	K (meq.l^{-1})	CO_3 (meq.l^{-1})	HCO_3 (meq.l^{-1})	SO_4 meq.l^{-1})	Cl (meq.l^{-1})
07/01			2.24	1430	8.2	6.8	15.5	0.0	4.8	3.6	13.9	0.2	0.0	3.8	5.2	13.5
28/01			4.33	2690	7.6	11.7	29.1	0.0	9.0	4.1	30.0	0.1	0.0	4.9	8.7	29.6
11/02			5.78	3520	7.4	11.1	29.4	0.0	11.0	10.4	36.2	0.2	0.0	5.3	11.7	40.8
26/02			2.21	1400	7.3	5.0	11.7	0.0	5.0	5.5	11.4	0.2	0.0	3.6	7.0	11.5
10/03			2.04	1270	7.3	3.3	8.1	0.0	4.7	7.3	8.2	0.2	0.0	3.6	5.8	11.0
24/03			2.64	1710	7.2*	6.1	16.4	0.0	6.3	5.3	14.6	0.2	0.0	8.0	2.7	15.7
14/04			2.47	1440	7.2	5.6	8.6	0.0	5.0	5.9	13.0	0.2	0.0	0.8	6.8	16.5
21/04			2.13	1380	7.5	6.5	15.1	0.0	4.0	4.1	13.0	0.1	0.0	4.4	6.3	10.5
05/05			2.29	1440	7.4	6.1	12.6	0.0	4.2	5.3	13.2	0.2	0.0	2.3	8.4*	12.2*
27/05			2.16	1390	7.6	6.3	14.8	0.0	5.0	3.6	13.0	0.0	0.0	4.4	5.2	12.0
04/06			2.46	1510	7.6	4.8	10.4	0.0	6.2	6.1	12.0	0.3	0.0	2.2	7.4	15.0
16/06			2.33	1500	7.1	6.2	15.4	0.0	5.0	4.5	13.6	0.2	0.0	5.2	5.6*	12.5*
01/07			2.73	1660	7.1	6.8	16.9	0.0	6.0	4.5	15.6	0.2	0.0	5.2	4.6	16.5
16/07			2.73	1780	7.3	9.2	21.8	0.0	3.6	4.9	19.0	0.2	0.0	4.8	7.7	15.2
01/08			2.82	1800	7.7	6.9	17.4	0.0	6.3	5.2	16.5	0.2	0.0	5.4	6.9	15.9
18/08		46.93	2.73	1750	7.4	6.6	16.6	0.0	5.2	5.6	15.3	1.1	0.0	5.4	6.2	15.6
22/09		46.19	2.73	1730	7.5	6.5	16.5	0.0	5.7	5.8	15.7	0.1	0.0	5.2	6.0	16.1
04/10		59.03	2.46	1620	7.3	10.0	23.6	0.2	3.2	2.8	17.4	1.2	0.0	6.2	3.6	14.8
27/10		62.99	2.18	1420	8.0	5.3	13.8	0.0	5.0	5.0	11.9	0.1	0.0	6.6	2.7	12.7
11/11		45.94	2.46	1600	7.8	5.8	15.5	0.0	5.1	6.0	13.7	0.2	0.0	7.6	2.1	15.3
24/11		43.47	3.28	2070	7.4	7.5	18.5	0.0	8.0	4.8	18.9	1.1	0.0	4.5	7.9*	20.4
07/12		34.33	3.19	2020	7.4	7.6	19.0	0.0	5.8	6.2	18.7	0.5	0.0	4.8	12.0	14.4
25/12		54.83	2.55	1650	8.1	9.1	21.7	0.0	3.9	3.7	17.8	0.1	0.0	5.4	5.9*	14.2

* corrected or estimated data

Table A 7-9. Discharge and water quality measurements EH 13, observation year 1980

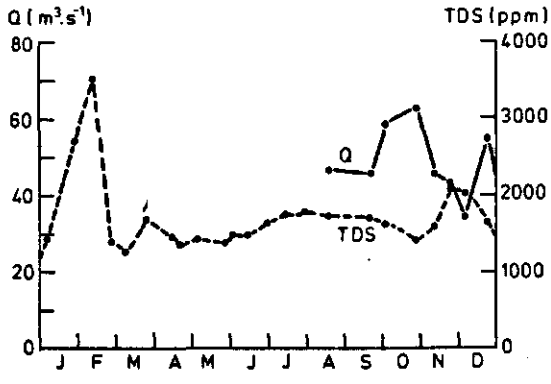


Fig. A 7-27. Discharge Q and salinity, TDS of EH 13, observation year 1980

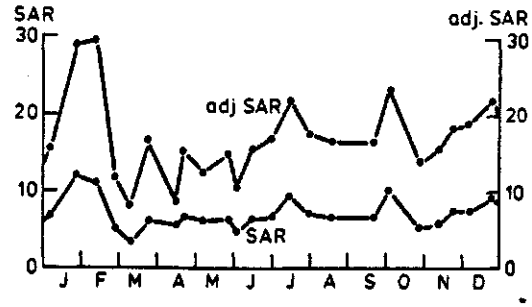


Fig. A 7-28. Sodium hazard, SAR and adj. SAR of EH 13, observation year 1980

7. 5. 2. EH 13, data presentation: monthly averages

MONTH	Q m^3/sec	EC	TDS	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
January		2. 73	1710	7. 9	8. 0	18. 7	0. 0	5. 7	3. 8	17. 5	0. 2	0. 0	4. 0	6. 1	17. 1
February		3. 22	2040	7. 3	7. 1	17. 5	0. 0	6. 9	7. 1	18. 7	0. 2	0. 0	4. 2	8. 5	20. 2
March		2. 33	1490	7. 2	4. 8	12. 3	0. 0	5. 5	6. 2	11. 6	0. 2	0. 0	5. 4	4. 6	13. 5
April		2. 33	1450	7. 3	5. 9	13. 3	0. 0	4. 7	5. 2	13. 2	0. 2	0. 0	3. 1	6. 3	13. 9
May		2. 20	1400	7. 5	6. 1	13. 7	0. 0	4. 6	4. 5	13. 0	0. 1	0. 0	3. 3	6. 7	12. 2
June		2. 41	1540	7. 2	5. 9	14. 3	0. 0	5. 6	4. 9	13. 6	0. 2	0. 0	4. 3	5. 8	14. 2
July		2. 70	1760	7. 3	7. 9	19. 4	0. 0	4. 9	4. 9	17. 5	0. 2	0. 0	5. 1	6. 7	15. 7
August	48. 48	2. 70	1760	7. 5	6. 7	16. 8	0. 0	5. 6	5. 5	15. 7	0. 7	0. 0	5. 4	6. 4	15. 7
September	47. 79	2. 66	1720	7. 5	6. 9	17. 4	0. 0	5. 2	5. 3	15. 9	0. 5	0. 0	5. 4	5. 7	15. 8
October	60. 52	2. 34	1520	7. 5	7. 1	17. 7	0. 0	4. 2	4. 1	14. 4	0. 6	0. 0	6. 4	3. 2	13. 7
November	46. 15	2. 75	1770	7. 6	6. 5	16. 8	0. 0	6. 2	5. 4	15. 6	0. 5	0. 0	6. 2	4. 8	16. 7
December	44. 21	2. 66	1780	7. 7	8. 3	20. 2	0. 0	4. 7	4. 6	17. 9	0. 3	0. 0	5. 1	7. 9	14. 5
AVERAGE	46. 54*	2. 54	1630	7. 4	6. 7	16. 4	0. 0	5. 2	5. 1	15. 1	0. 3	0. 0	4. 9	5. 9	14. 9

* For the period January - July data of 1981 have been used for the calculation of the average

Table A 7-10. Average monthly discharge and water quality data EH 13, observation year 1980

7. 5. 3. EH 13, presentation of empirical relationships

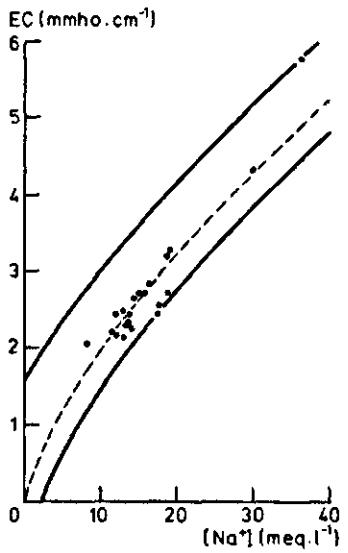


Fig. A 7-29. EC-Na concentration relation EH 13, observation year 1980

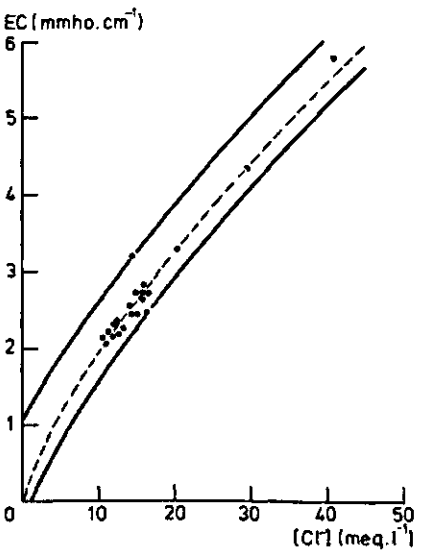


Fig. A 7-30. EC-Cl concentration relation EH 13, observation year 1980

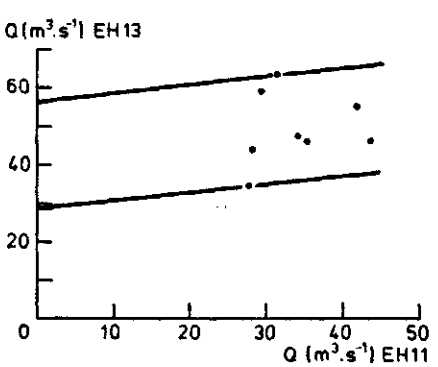


Fig. A 7-31. Discharge-double mass relation EH 13 and EH 14, observation year 1980

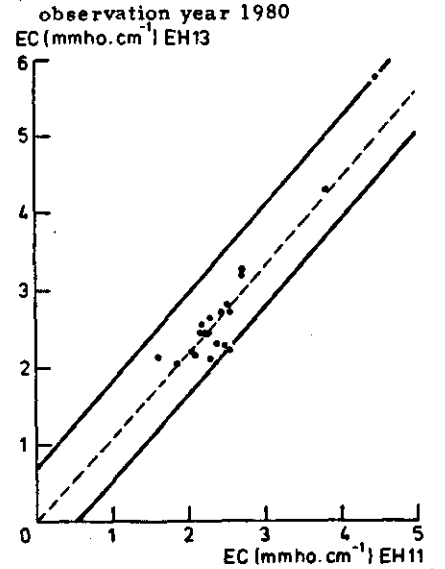


Fig. A 7-32. Salinity-double mass relation EH 13 and EH 14, observation year 1980

7. 6. MG 09, pump station No. 4: data presentation

7. 6. 1. MG 09, detailed data presentation

Date	Depth (m)	Discharge ($m^3 . sec^{-1}$)	EC (mmho. cm^{-1})	TDS (ppm)	pH	SAR	adj. SAR	RSC ($meq. l^{-1}$)	Ca ($meq. l^{-1}$)	Mg ($meq. l^{-1}$)	Na ($meq. l^{-1}$)	K ($meq. l^{-1}$)	CO_3 ($meq-l^{-1}$)	HCO_3 ($meq. l^{-1}$)	SO_4 $meq. l^{-1}$)	Cl ($meq. l^{-1}$)
16/04			1. 42	920	7. 4	4. 5	10. 0	0. 0	3. 5	2, 7	8. 0	0. 2	0. 0	3. 8	1. 6	9. 0
06/05			2. 13	1320	7. 8	6. 0	13. 5	0. 0	4. 2	4. 3	12. 3	0. 2	0. 0	3. 6	4. 2	13. 2
20/05			1. 38	910	7. 4	2. 8	6. 3	0. 0	3. 5	3. 7	5. 3	1. 5	0. 0	3. 6	2. 2	8. 2
09/06			1. 25*	710	7. 6	4. 1	8. 7	0. 0	2. 1	2. 4	6. 1	0. 2	0. 0	4. 0	0. 7	6. 1
22/06			1. 92	1290	7. 7	6. 0	14. 1	0. 0	2. 8	4. 7	11. 6	0. 4	0. 0	4. 8	6. 4	8. 3
08/07			1. 48	960	7. 6	4. 0	9. 3	0. 0	2. 6	4. 6	7. 5	0. 2	0. 0	4. 7	1. 5	8. 7
25/07			1. 43	960	8. 0	4. 8	11. 2	0. 0	3. 2	2. 8	8. 4	0. 1	0. 0	5. 0	1. 7	7. 8
07/08			1. 27	870	7. 3	3. 6	8. 5	0. 0	4. 7	1. 8	6. 5	0. 1	0. 0	5. 0	0. 9	7. 2
30/08			1. 53*	910	7. 6	5. 4	12. 1	0. 0	3. 2	1. 8	8. 6	0. 1	0. 0	4. 7	1. 4	7. 6
14/09			1. 40	930	7. 6	4. 7	10. 8	0. 0	3. 2	2. 4	7. 9	0. 6	0. 0	4. 8	0. 6	8. 7
27/09			1. 51	950	7. 6	2. 2	5. 6	0. 0	3. 2	6. 8	4. 9	0. 1	0. 0	5. 4	1. 5	8. 1
15/10			1. 04	710	7. 4	2. 2	5. 1	0. 0	3. 7	2. 8	3. 9	0. 1	0. 0	4. 9	1. 0	4. 6
06/11			1. 40	920	7. 6	3. 6	8. 5	0. 0	5. 5	1. 5	6. 7	0. 3	0. 0	5. 0	0. 4	8. 6
20/11			1. 40	910	7. 4	1. 6	3. 9	0. 0	3. 9	6. 9	3. 7	0. 2	0. 0	4. 0	2. 4	8. 3
30/12			2. 28	1530	7. 5	9. 4	21. 1	0. 0	4. 4	1. 8	16. 5	0. 2	0. 0	4. 7	8. 3	9. 9

* corrected or estimated data

Table A 7-11. Water quality measurements MG 09, observation year 1980

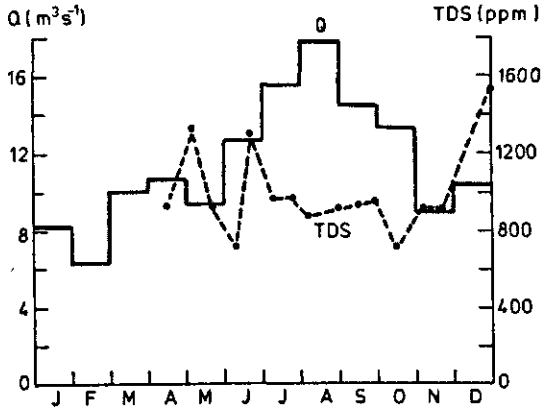


Fig. A 7-33. Discharge Q and salinity TDS of MG 09, observation year 1980

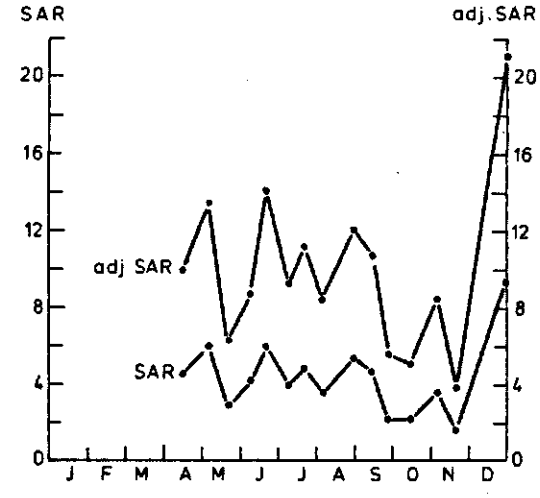


Fig. A 7-34. Sodium hazard, SAR and adj. SAR of MG 09, observation year 1980

7. 6. 2. MG 09, data presentation: monthly averages

MONTH	Q m^3/sec	EC	TDS	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
January	8. 23														
February	6. 26														
March	9. 97														
April	10. 62	1. 68	1010	7. 5	5. 0	11. 0	0. 0	3. 5	3. 2	9. 1	0. 2	0. 0	3. 6	1. 9	10. 5
May	9. 28	1. 72	1070	7. 5	4. 3	9. 7	0. 0	3. 7	3. 9	8. 3	0. 8	0. 0	3. 8	2. 8	10. 1
June	12. 63	1. 51	990	7. 6	4. 9	11. 1	0. 0	2. 5	3. 7	8. 6	0. 3	0. 0	4. 4	3. 3	7. 4
July	15. 53	1. 51	970	7. 7	4. 4	10. 3	0. 0	3. 0	3. 6	8. 0	0. 2	0. 0	4. 9	1. 7	8. 2
August	17. 84	1. 37	880	7. 4	4. 3	10. 0	0. 0	4. 0	1. 8	7. 4	0. 1	0. 0	4. 8	1. 1	7. 4
September	14. 46	1. 51	960	7. 6	3. 9	9. 3	0. 0	3. 3	3. 8	7. 3	0. 3	0. 0	5. 2	0. 9	8. 6
October	13. 30	1. 14	750	7. 5	2. 3	5. 5	0. 0	3. 7	3. 2	4. 3	0. 1	0. 0	4. 7	1. 0	5. 6
November	8. 92	1. 54	960	7. 5	2. 7	6. 5	0. 0	4. 6	4. 6	5. 7	0. 2	0. 0	4. 5	2. 0	8. 6
December	10. 40	1. 89	1280	7. 5	6. 3	14. 5	0. 0	4. 0	3. 2	12. 0	0. 2	0. 0	4. 3	6. 1	9. 0
AVERAGE	11. 48	1. 73	1100	7. 5*	4. 6	10. 9	0. 0	4. 0*	3. 7*	9. 0*	0. 3*	0. 0*	4. 6*	2. 6*	9. 8*

* For the period of January - March data of 1981 have been used for the calculation of the average

Table A 7-12. Average monthly discharge and water quality data MG 09, observation year 1980

7. 6. 3. MG 09, presentation of empirical relationships

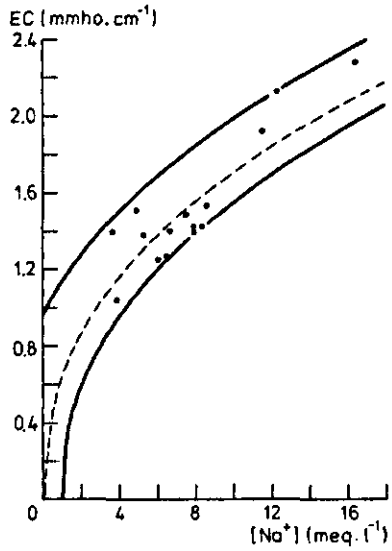


Fig. A 7-35. EC-Na concentration relation MG 09, observation year 1980

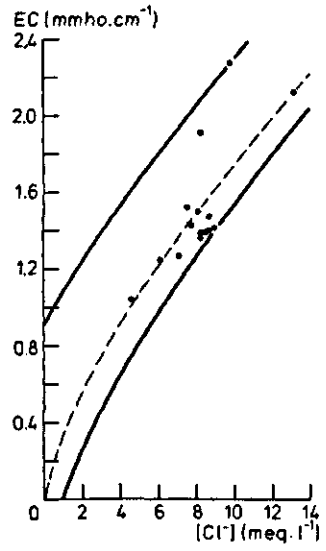


Fig. A 7-36. EC-Cl concentration relation MG 09, observation year 1980

7. 7. WE 10, Edko pump station: data presentation

7. 7. 1. WE 10, detailed data presentation

Date	Depth (m)	Discharge ($m^3.sec^{-1}$)	EC (mmho.cm^{-1})	TDS (ppm)	pH	SAR	adj. SAR	RSC ($meq.l^{-1}$)	Ca ($meq.l^{-1}$)	Mg ($meq.l^{-1}$)	Na ($meq.l^{-1}$)	K ($meq.l^{-1}$)	CO_3 ($meq.l^{-1}$)	HCO_3 ($meq.l^{-1}$)	SO_4 $meq.l^{-1}$)	Cl ($meq.l^{-1}$)
Jan I		1. 91														
Jan II		2. 45														
Jan III		1. 64														
Feb I		2. 18														
Feb II		1. 96														
Feb III		1. 86														
Mar I		1. 42														
12/03		2. 60	7. 82	4900	7. 7	19. 0	48. 7	0. 0	6. 8	13. 2	60. 0	1. 0	0. 0	5. 0	14. 6	61. 4
24/03		5. 64	3. 91	2540	7. 2	13. 1	35. 1	0. 0	4. 5	5. 5	29. 4	0. 8	0. 0	9. 6	0. 4	30. 2
09/04		4. 42	4. 93	3450	7. 4	14. 8	37. 0	0. 0	4. 5	10. 2	40. 0	0. 8	0. 0	5. 0	15. 0	35. 5
Apr II		4. 46														
22/04		4. 62	4. 67	2960	7. 7	21. 8	42. 5	0. 0	3. 2	3. 4	39. 6	0. 6	0. 0	2. 8	15. 0	29. 0
May I		5. 05														
13/05		5. 47	3. 83	2370	7. 7	9. 4	24. 1	0. 0	4. 7	8. 8	24. 4	0. 4	0. 0	5. 6	7. 1*	25. 6*
21/05		4. 99	3. 74	2280	6. 7	9. 2	23. 7	0. 0	7. 1	6. 4	24. 0	0. 2	0. 0	5. 6	1. 9	30. 2
04/06		6. 35	3. 15	1970	7. 6	6. 9	17. 2	0. 0	3. 8	8. 8	17. 2	1. 8	0. 0	4. 8	6. 1*	20. 7*
14/06		6. 06	4. 30	2580	7. 9	10. 1	24. 4	0. 0	3. 0	11. 7	27. 5	1. 1	0. 0	3. 7	6. 2	33. 4
Jun III		6. 81														
02/07		8. 95	4. 00	2630	7. 6	10. 1	27. 5	0. 0	5. 1	9. 3	27. 0	0. 6	0. 0	8. 0	6. 4	27. 6
16/07		8. 84	3. 55	2280	7. 8	11. 7	29. 6	0. 0	5. 1	4. 4	25. 5	0. 6	0. 0	6. 8	6. 3	22. 5
Jul III		8. 93														
02/08		9. 42	3. 45	2160	7. 7	10. 9	27. 5	0. 0	4. 7	5. 3	24. 3	0. 2	0. 0	6. 5	4. 1	23. 9
18/08		9. 09	3. 28	2080	7. 6	9. 9	24. 9	0. 0	3. 2	6. 9	22. 2	0. 6	0. 0	6. 1	6. 4	20. 4
Aug III		8. 94														
02/09		10. 28	2. 91	1950	7. 4	10. 4	25. 4	0. 0	4. 6	3. 9	21. 4	0. 4	0. 0	5. 9	6. 5	17. 9
18/09		10. 29	3. 28	2070	7. 6	10. 5	25. 8	0. 0	3. 4	6. 1	22. 9	0. 5	0. 0	5. 6	5. 9	21. 4
27/09		10. 03	3. 28	2110	7. 7	7. 8	20. 8	0. 0	4. 7	8. 3	20. 0	0. 4	0. 0	6. 8	6. 3	20. 3
Oct I		7. 09														
13/10		5. 98	3. 55	2200	7. 5	8. 8	23. 8	0. 0	4. 7	8. 3	22. 5	0. 2	0. 0	7. 8	1. 6	26. 3
Oct III		5. 22														
02/11		5. 19	4. 00	2510	7. 5	9. 4	25. 5	0. 0	4. 5	9. 5	25. 0	1. 1	0. 0	7. 4	6. 3	26. 4
16/11		6. 24	4. 55	2810	8. 0	10. 8	27. 7	0. 0	6. 8	8. 7	30. 0	0. 2	0. 0	5. 3	9. 5*	30. 9
Nov III		5. 41														
03/12		4. 91	5. 00	3170	7. 4	15. 6	37. 7	0. 0	4. 2	7. 3	37. 5	1. 1	0. 0	4. 8	15. 9	29. 4
17/12		2. 60	6. 55	4350	7. 1	19. 5	48. 1	0. 0	5. 2	10. 1	54. 0	0. 8	0. 0	4. 7	19. 5*	45. 9
30/12		2. 44*	6. 37	4460	7. 9	19. 0	47. 3	0. 0	3. 7	12. 8	54. 6	0. 7	0. 0	4. 7	22. 6*	44. 5

* corrected or estimated data

Table A 7-13. Discharge and water quality measurements WE 10, observation year 1980

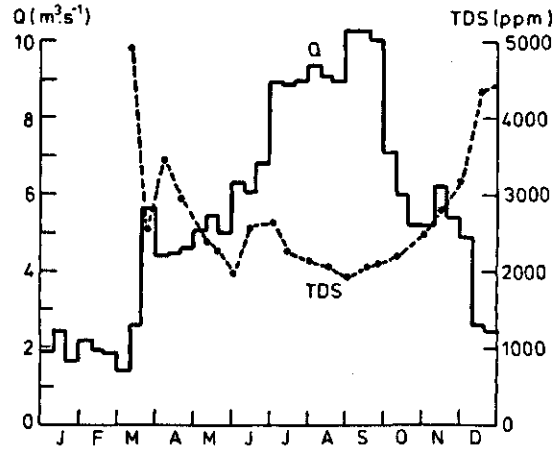


Fig. A 7-37. Discharge Q and salinity TDS of WE 10, observation year 1980

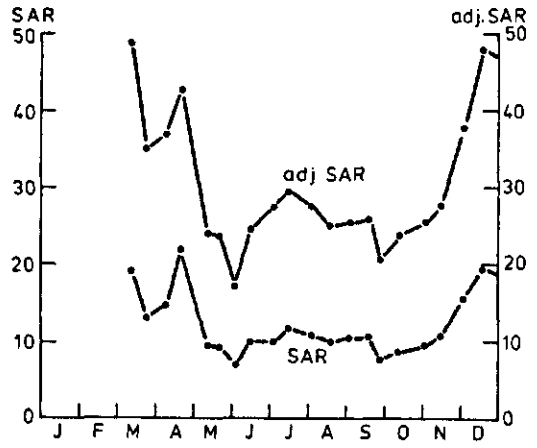


Fig. A 7-38. Sodium hazard, SAR and adj. SAR of WE 10, observation year 1980

7. 7. 2. WE 10, data presentation: monthly averages

MONTH	Q m^3/sec	EC	TDS	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
January	1. 99														
February	2. 00														
March	3. 30	6. 27	3880	7. 2	16. 4	45. 1	0. 0	6. 1	9. 7	46. 1	1. 0	0. 0	8. 8	6. 9	47. 2
April	4. 50	4. 97	3180	7. 5	16. 7	39. 6	0. 0	4. 1	6. 9	39. 1	0. 7	0. 0	4. 6	13. 7	32. 5
May	5. 16	3. 93	2410	7. 1	9. 9	25. 2	0. 0	5. 3	7. 8	25. 4	0. 6	0. 0	5. 4	6. 2	27. 5
June	6. 41	4. 31	2650	7. 7	9. 7	25. 5	0. 0	4. 3	10. 9	26. 8	1. 2	0. 0	5. 9	6. 8	30. 5
July	8. 91	3. 72	2370	7. 7	11. 0	28. 7	0. 0	5. 0	6. 0	25. 9	0. 5	0. 0	7. 1	5. 9	24. 4
August	9. 14	3. 38	2160	7. 6	10. 4	26. 3	0. 0	4. 3	5. 9	23. 4	0. 4	0. 0	6. 4	6. 1	21. 5
September	10. 20	3. 19	2030	7. 5	9. 6	24. 1	0. 0	4. 1	6. 0	21. 6	0. 4	0. 0	6. 0	6. 1	20. 0
October	6. 07	3. 80	2360	7. 5	8. 9	24. 2	0. 0	4. 9	9. 0	23. 5	0. 5	0. 0	7. 8	4. 1	26. 0
November	5. 61	4. 45	2880	7. 7	11. 3	29. 3	0. 0	5. 8	8. 7	30. 5	0. 6	0. 0	5. 8	10. 0	29. 8
December	3. 29	5. 83	3790	7. 3	17. 6	42. 9	0. 0	4. 4	9. 3	46. 0	0. 9	0. 0	4. 7	18. 2	37. 7
AVERAGE	5. 56	4. 35	2770	7. 4*	12. 0	31. 0	0. 0	4. 9*	8. 2*	30. 6*	0. 6*	0. 0*	6. 4*	8. 7*	29. 2*

* For the period of January - February data of 1981 have been used for the calculation of the average

Table A 7-14. Average monthly discharge and water quality data WE 10, observation year 1980

7. 7. 3. WE 10, presentation of empirical relationships

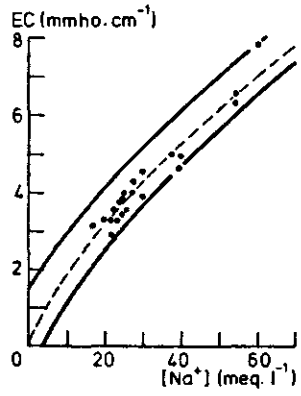


Fig. A 7-39. EC-Na concentration relation WE 10, observation year 1980

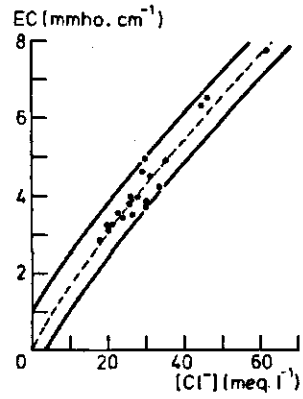


Fig. A 7-40. EC-Cl concentration relation WE 10, observation year 1980

7. 8. WE 11, Bosseili pump station: data presentation

7. 8. 1. WE 11, detailed data presentation

Date	Depth (m)	Discharge ($m^3 . sec^{-1}$)	EC ($mmho . cm^{-1}$)	TDS (ppm)	pH	SAR	adj. SAR	RSC ($meq . l^{-1}$)	Ca ($meq . l^{-1}$)	Mg ($meq . l^{-1}$)	Na ($meq . l^{-1}$)	K ($meq . l^{-1}$)	CO_3 ($meq . l^{-1}$)	HCO_3 ($meq . l^{-1}$)	SO_4 $meq . l^{-1}$)	Cl ($meq . l^{-1}$)
Jan I		2. 01														
Jan II		3. 09														
Jan III		1. 93														
Feb I		2. 53														
Feb II		4. 17														
Feb III		4. 78														
Mar I		4. 69														
12/03		.8. 23	2. 53*	1380	7. 7	8. 4	17. 4	0. 0	3. 0	3. 7	15. 3	0. 3	0. 0	3. 0	3. 5	15. 8
24/03		7. 75	2. 21	1460	7. 4	7. 7	19. 3	0. 1	3. 5	3. 6	14. 6	0. 5	0. 0	7. 2	1. 5	13. 5
09/04		8. 01	2. 55	1590	7. 4	7. 5	17. 4	0. 0	3. 8	5. 3	16. 0	0. 5	0. 0	4. 0	4. 6	17. 0
Apr II		9. 78														
22/04		9. 78	1. 79	1160	7. 9	6. 3	13. 0	0. 0	3. 4	3. 1	11. 4	0. 2	0. 0	2. 8	5. 3	10. 0
May I		9. 61														
13/05		10. 27	1. 96	1170	7. 9	5. 1	12. 0	0. 0	3. 7	4. 3	10. 2	0. 4	0. 0	4. 4	2. 1	12. 1
21/05		6. 08	1. 87	1230	6. 7	4. 2	10. 6	0. 0	7. 4	2. 0	9. 2	0. 2	0. 0	5. 2	3. 5	10. 1
04/06		9. 06	1. 21	780	7. 4	2. 4	5. 7	0. 0	3. 5	3. 7	4. 6	0. 2	0. 0	4. 4	1. 4	6. 2
14/06		8. 87	2. 04	1280	7. 9	4. 0	9. 4	0. 0	5. 0	5. 7	9. 2	0. 5	0. 0	3. 6	5. 4	11. 4
Jun III		11. 02														
02/07		10. 71	1. 87	1230	7. 6	5. 5	13. 8	0. 0	4. 1	3. 5	10. 7	0. 4	0. 0	6. 8	0. 4	11. 5
16/07		10. 96	1. 41	950	7. 6	4. 7	11. 1	0. 0	2. 0	3. 8	8. 0	0. 3	0. 0	5. 8	1. 4	6. 9
Jul III		7. 47														
02/08		7. 28	1. 65	1080	7. 2	5. 3	12. 7	0. 0	3. 2	3. 4	9. 7	0. 2	0. 0	5. 4	1. 7	9. 4
18/08		11. 45	1. 57	1040	7. 3	4. 9	11. 6	0. 0	3. 7	2. 8	8. 8	0. 4	0. 0	5. 3	1. 7	8. 7
Aug III		11. 38														
02/09		11. 60	1. 53	1010	7. 4	3. 9	9. 6	0. 0	3. 7	3. 8	7. 5	0. 4	0. 0	5. 9	0. 8	8. 7
18/09		11. 10	1. 82	1210	7. 8	6. 0	14. 5	0. 0	5. 7	1. 1	11. 0	0. 4	0. 0	6. 0	1. 5	10. 7
27/09		9. 18	2. 00	1290	7. 3	5. 4	13. 3	0. 0	4. 2	4. 3	11. 2	0. 3	0. 0	5. 2	3. 5	11. 3
Oct I		10. 87														
13/10		5. 61	1. 82	1150	8. 4	5. 0	12. 0	0. 0	4. 2	3. 8	10. 0	0. 2	0. 0	4. 8	1. 2	12. 2
Oct III		5. 25														
02/11		3. 63	1. 67	1110	7. 2	5. 0	12. 2	0. 0	3. 7	3. 3	9. 3	0. 4	0. 0	6. 2	1. 6	8. 9
16/11		4. 55	2. 18	1400	7. 8	5. 5	13. 3	0. 0	4. 0	5. 5	12. 0	0. 5	0. 0	4. 6	5. 0*	12. 4*
Nov III		5. 15														
03/12		5. 05	2. 00	1300	7. 5	6. 7	15. 5	0. 0	3. 2	3. 9	12. 7	0. 4	0. 0	4. 4	4. 5*	11. 3*
17/12		4. 46	3. 64	2340	7. 1	11. 1	28. 1	0. 0	4. 8	6. 2	26. 0	0. 5	0. 0	6. 2	5. 3	26. 0
30/12		4. 16	3. 37	2280	7. 6	11. 4	26. 8	0. 0	3. 2	6. 9	25. 6	0. 5	0. 0	4. 3	10. 7	21. 2

* corrected or estimated data

Table A 7-15. Discharge and water quality measurements WE 11, observation year 1980

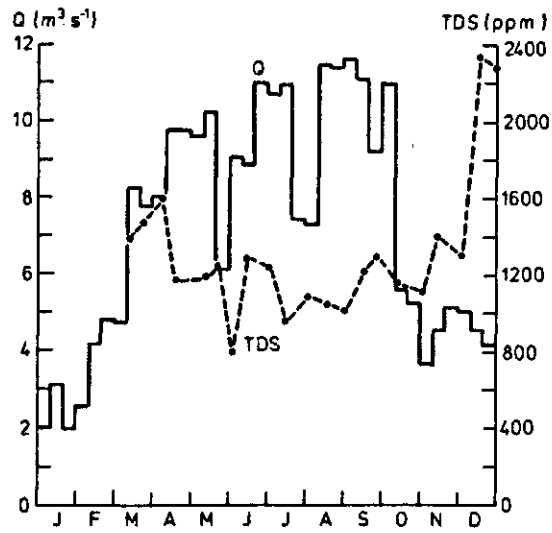


Fig. A 7-41. Discharge Q and salinity TDS of WE 11, observation year 1980

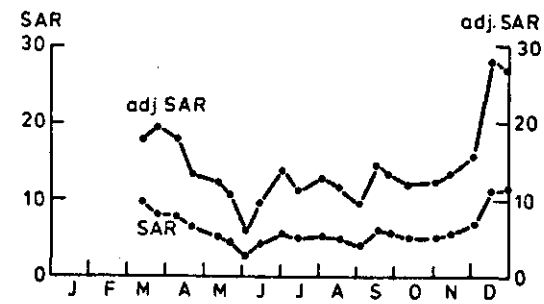


Fig. A 7-42. Sodium hazard, SAR and adj. SAR of WE 11, observation year 1980

7. 8. 2. WE 11, data presentation: monthly averages

MONTH	Q m^3/sec	EC	TDS	pH	SAR	adj. SAR	RSC	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl
January	2. 33														
February	3. 79														
March	6. 92	2. 61	1610	7. 5	8. 5	20. 4	0. 0	3. 7	4. 3	17. 0	0. 4	0. 0	5. 3	3. 0	17. 1
April	9. 19	2. 10	1300	7. 6	6. 7	14. 8	0. 0	3. 5	3. 9	12. 9	0. 3	0. 0	3. 5	4. 5	12. 6
May	8. 57	1. 80	1130	7. 2	4. 7	11. 0	0. 0	4. 5	3. 5	9. 3	0. 3	0. 0	4. 4	2. 7	10. 5
June	9. 65	1. 75	1110	7. 6	4. 0	9. 7	0. 0	4. 2	4. 4	8. 3	0. 4	0. 0	4. 7	2. 8	9. 8
July	9. 64	1. 66	1090	7. 5	5. 1	12. 5	0. 0	2. 9	3. 8	9. 4	0. 3	0. 0	6. 2	1. 3	8. 9
August	10. 08	1. 64	1070	7. 3	4. 8	11. 6	0. 0	3. 7	3. 2	8. 9	0. 4	0. 0	5. 6	1. 6	9. 0
September	10. 63	1. 80	1170	7. 5	5. 1	12. 6	0. 0	4. 7	2. 7	9. 9	0. 4	0. 0	5. 8	1. 7	10. 2
October	7. 18	1. 49	920	7. 7	4. 5	10. 0	0. 0	3. 2	3. 0	7. 9	0. 2	0. 0	4. 0	1. 5	8. 8
November	4. 44	2. 02	1300	7. 5	5. 6	13. 6	0. 0	3. 7	4. 6	11. 5	0. 4	0. 0	4. 9	4. 0	11. 3
December	4. 54	3. 17	2010	7. 3	10. 0	24. 2	0. 0	3. 9	5. 6	21. 8	0. 5	0. 0	5. 1	6. 5	20. 2
AVERAGE	7. 25	2. 90	1840	7. 4*	9. 1	22. 1	0. 0	4. 2*	4. 9	19. 5	0. 4	0. 0*	5. 2*	5. 8*	16. 0*

* For the period January - February data of 1981 have been used for calculating the average

Table A 7-16. Average monthly discharge and water quality data WE 11, observation year 1980

7. 8. 3. Presentation of empirical relationships

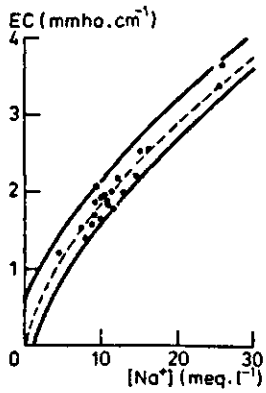


Fig. A 7-43. EC-Na concentration relation WE 11, observation year 1980

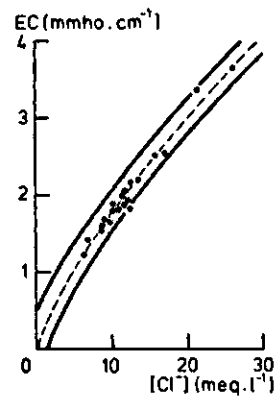


Fig. A 7-44. EC-Cl concentration relation WE 11, observation year 1980

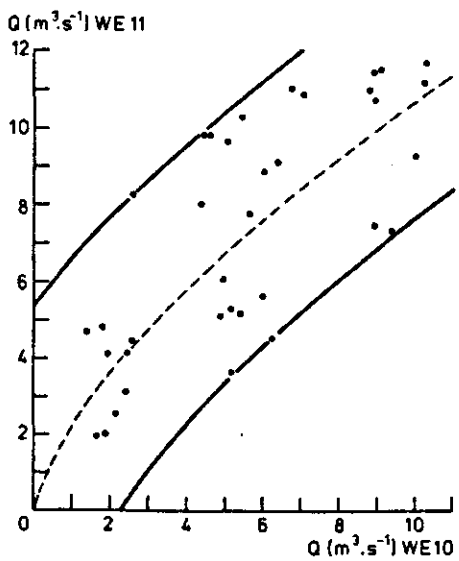


Fig. A 7-45. Discharge-double mass relation WE 11 and WE 10, observation year 1980

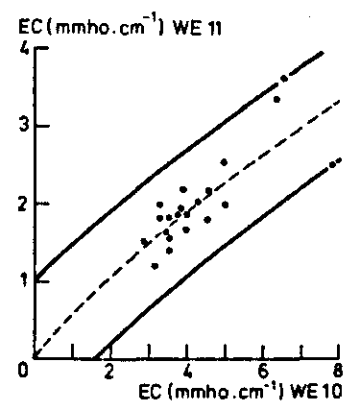


Fig. A 7-46. Salinity-double mass relation WE 11 and WE 10, observation year 1980

ANNEX 8: HP 97 PROGRAMMES

8.1. Programme "FLOATS'

User Intructions

STEP	INSTRUCTIONS	INPUT DATA / UNITS	KEYS	OUTPUT DATA / UNITS
1	Read the data card of the measurement point			
2	Read the card with programme 'Floats'			
3	Read Hm	Hm	f B	
4	If there are waterplants in the subsection set flag 2		f A	
5	Read travel time float first subsection and calculate A_s and the fractional discharge	t*	A	
6	Repeat steps 4 and 5 for all sub sections			
7	Print results		B	D A Q v_f
8	If the next calculation concerns the same measurement point reset the counter: and continue from step 3 - step 7 If the next calculation concerns another measurement point, read the pertinent data card and continue from step 3 - step 7	n	STO I	
	* If there are waterplants in the sub section, the travel time has not been measured. Take in this case the average of t from the sub section on the left and right side of the sub section. If the travel time has not been determined adjacent to the left and right banks of the drain due to waterplants, or because the sub section is (nearly) dry and the water is not flowing, do not take t = 0, but enter the travel time t by pressing:		EEX 9 A	

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	* LBL a	21 16 11	This programme sets flag 2 as a signal that there are waterplants in the sub section
002	SF 2	16 21 02	
003	RTN	24	End of programme
004	* LBL b	21 16 12	Initialisation programme; reads Hm
005	STO A	35 11	Hm
006	0	00	
007	STO 0	35 00	$\Sigma A_w = 0$
008	STO 1	35 01	$\Sigma Q = 0$
009	RTN	24	End of programme
010	* LBL A	21 11	Main programme
011	ISZ I	16 26 46	i = i+1
012	RCl i	36 45	100 w.As
013	ENT↑	-21	
014	INT	16 34	100 w
015	STOD	35 14	
016	-	-45	0.As
017	EEX	-23	
018	2	02	100
019	x	-35	A_s (m^2)
020	STOE	35 15	
021	R↓	-31	t
022	RCLD	36 14	100 w
023	EEX	-23	
024	2	02	100
025	+	-24	w (m)
026	STOD	35 14	
027	R↓	-31	t
028	RCLB	36 12	B
029	x ⇄ y	-41	t
030	+	-24	V_s = B/t
031	.	-62	
032	8	08	
033	5	05	
034	x	-35	v = 0.85 Vs
035	RCLD	36 14	w
036	RCLA	36 11	Hm
037	x	-35	A_d = w Hm
038	RCLE	36 15	A_s
039	x ⇄ y	-41	A_d
040	-	-45	$A_w = A_s - A_d$
041	x < 0 ?	16-41	If A_w < 0, the sub section is dry. Return to label A for the next sub section
042	RTN	24	If A_w > 0, programme step 42 is skipped
043	ST+0	35-55 00	$\Sigma A_w = \Sigma A_w + A_w$
044	F 2?	16 23 02	If flag 2 is set (waterplants in the section) go to sub routine 1 for reduction of A_w. If
045	GSB 1	23 01	flag 2 is not set, programme step 45 is skipped
046	x < 0 ?	16-45	If A_w < 0, the sub section is completely filled with waterplants. Return to label A
047	RTN	24	for the next sub section. If A_w > 0, programme step 47 is skipped
048	x	-35	$Q = \bar{v} A_w$
049	ST + 1	35 55 01	$\Sigma Q = \Sigma Q + Q$
050	RTN	24	End of main programme

REGISTERS

0	1	2	3	4	5	6	7	8	9
ΣA_w	ΣQ		←			Reserved for Bridge Data			→

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
←				Reserved for Bridge Data					→

A	B	C	D	E	I
Hm	B	D + Hm	100 w |w	A_s	i

STEP	KEY ENTRY	KEY CODE	COMMENTS
051	* LBL I	21 01	Sub routine for diminshing A_w because of floating waterplants
052	R	-31	$\bar{v}$
053	RCLA	36 11	Hm
054	.	-62	
055	5	05	
056	+	-55	Hm + 0.5
057	RCLD	36 14	w
058	x	-35	(Hm + 0.5) w = A_d
059	RCLE	36 15	A_s
060	x ⇄ y	-41	A_d
061	-	-45	$A_w = A_s - w$ (Hm + 0.5)
062	RTN	24	End of sub routine
063	* LBL B	21 12	Programme for average velocity
064	SPC	16-11	
065	RCLC	36 13	D + Hm (= distance bridge surface - drain bottom
966	RCLA	36 11	Hm
067	-	-45	D
068	PRTX	-14	Print D
069	RCL 0	36 00	A = ΣA_w
070	PRTX	-14	Print A
071	RCL 1	36 01	Q = ΣQ
072	PRTX	-14	Print Q
073	RCL 0	36 00	A
074	÷	-24	$\bar{v}_f$ = Q/A
075	DSP 3	-63 03	
076	PRTX	-14	Print $\bar{v}_f$
077	DSP 2	-63 02	
078	RTN	24	End of programme

REGISTERS

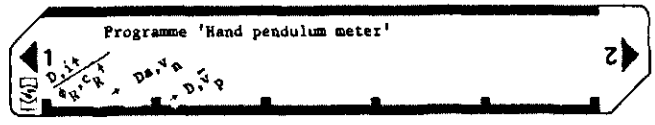
0	1	2	3	4	5	6	7	8	9
ΣA_w	ΣQ	← Reserved for bridge data →							

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
← Reserved for bridge data →									

A	B	C	D	E	I
Hm	B	D + Hm	w	A_s	i

8.2 Programme 'HAND PENDULUM METER'

User Intructions



STEP	INSTRUCTIONS	INPUT DATA / UNITS	KEYS	OUTPUT DATA / UNITS
1	Insert card with programme 'Hand pendulum meter'			
2	Insert card with data 'Hand pendulum meter'			
3	Read waterdepth D at reference point and chose resistance body type i : K = 1; L = 2; M = 3; N = 4	D i	ENTER↑ f A	
4	Read a measured angle ϕ_R and cable length c_R, starting from the water surface (lowest value of c_R first), proceding downward. Calculate depth and velocity	ϕ_R c_R	ENTER↑ A	c_R D_a v_n
4a	If during the measurements the resistance body reached the bottom of the drain (the programme calculates D_a and compares with D) the output of step 4 changes to			c_R $\bar{v}_p$
5	Repeat step 4 until all data are entered, or until the programme calculates the final results (step 4a)*			
6	If the programme did not yet give the final results (step 4a) calculate the average velocity:**		B	D $\bar{v}_p$
7	For the next measurement report steps 3 - 6			
	* If a mistake has been made with the data entry (step 4) the *flags 0 and 1* have to be cleared:		f CLF 0 f CLF 1	
	and the procedure starts again with step 3			
	** If odd results are obtained (negative average velocity), the calculated velocity distribution is reversed (velocity maximum near the drain bottom). Ignore in this case the result and calculate the arithmetic average of v_n:		f P ⇄ S RCL 9 f P ⇄ S RCL I ÷	Σ v n $\bar{v}_p$

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	* LBL a	21 16 11	Sub programme for initializing the calculator, reading the waterdepth and scoring the constants of the resistance body used
002	CLRG	16-53	Remove contents of the registers 0 - 9 and A - I
003	9	09	
004	+	-55	i + 9 (i = number of the resistance body)
005	STO I	35 46	
006	R↓	-31	D
007	STO D	35 14	
008	RCL i	36 45	(50 H).(1000 K_1)(1000 K_2) resistance body i
009	ENT ↑	-21	
010	INT	16 34	50 H
011	-	-45	0.(1000 K_1)(1000 K_2)
012	LST X	16-63	50 H
013	EEX	-23	
014	2	02	100
015	+	-24	0.5 H
016	STO 0	35 00	
017	R↓	-31	0
018	EEX	-23	
019	4	04	10000
020	x	-35	(1000 K_1).(1000 K_2)
021	ENT↑	-21	
022	INT	16 34	1000 K_1
023	-	-45	0.(1000 K_2)
024	LST X	16-63	1000 K_1
025	EEX	-23	
026	3	03	1000
027	+	-24	K_1
028	STO I	35 01	
029	R↓	-31	0.(1000 K_2)
030	1	01	
031	0	00	10
032	x	-35	K_2
033	STO 2	35 02	
034	0	00	
035	STO I	35 46	n-1=0
036	P ↔ S	16 51	Change register 0 - 9 with S_0 - S_9
037	STO 6	35 06	$\Sigma \ln(D-D_a) = 0$
038	STO 7	35 07	$\Sigma\{\ln(D-D_a)\}^2 = 0$
039	STO 8	35 08	$\Sigma v \ln(D-D_a) = 0$
040	STO 9	35 09	$\Sigma v = 0$
041	P↔ S	16-51	Change register 0 - 9 with S_0 - S_9 (original position)
042	RTN	24	End of sub programme
043	* LBL A	21 11	Main programme, calculates depth and velocity
044	DSP 0	-63 00	
045	PRT X	-14	c_R (depth counter reading in dm)
046	DSP 2	-63 02	
047	x↔ y	-41	ϕ_R
048	STO A	35 11	
049	x ↔ y	-41	c_R

REGISTERS

0	1	2	3	4	5	6	7	8	9
0.5 H	K_1	K_2							
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
← Reserved	for resistance body data →					$\Sigma \ln(D-D_a)$	$\Sigma\{\ln(D-Da)\}^2$	$\Sigma v \ln(D-Da)$	Σv
K: 7.33150666	L: 6.36501825	M: 6.08603640	N: 6.08556300						

A	B	C	D	E	I
ϕ_R			D		i+9 | n

STEP	KEY ENTRY	KEY CODE	COMMENTS
050	F 17	16 23 01	} If flag 1 is set, go to LBL 1 (flag 1 is set after the first set of data)
051	GTO 1	22 01	} If not (first set of data c_R and ϕ_R), skip step 051
052	STO 9	35 09	$c_R(0) = c_R$
053	* LBL 1	21 01	
054	RCL 9	36 09	$c_R(0)$
055	-	-45	$c_R - c_R(0) = 10\ L_n$ (length of cable below water surface)
056	1	01	
057	0	00	10
058	+	-24	$L_n = \sum_{n=1}^{n} \Delta L_n$
059	RCL 5	36 05	$\sum_{n=1}^{n-1} \Delta L_n$
060	-	-45	ΔL_n
061	ST+5	35-55 05	$\sum_{n=1}^{n} \Delta L_n$
062	RCL 3	36 03	v_{n-1}
063	x^2	53	v_{n-1}^2
064	RCL 1	36 01	K_1
065	x	-35	$K_1 v_{n-1}^2 = \alpha_n$
066	x	-35	$\alpha_n \Delta L_n$
067	RCL 4	36 04	$\sum_{n=1}^{n-1} \alpha_n \Delta L_n$
068	+	-55	$\sum_{n=1}^{n} \alpha_n \Delta L_n$
069	STO 4	35 04	
070	2	02	
071	÷	-24	$0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n$
072	-	-45	$\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n$
073	COS	42	$\cos\left(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n\right)$
074	STO 6	35 06	
075	3	03	
076	Y^x	31	$\cos^3\left(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n\right)$
077	RCL 4	36 04	$\sum_{n=1}^{n} \alpha_n \Delta L_n$
078	x	-35	$\phi_c = \cos^3\left(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n\right) \sum_{n=1}^{n} \alpha_n \Delta L_n$
079	RCL A	36 11	ϕ_R
080	x y	-41	ϕ_c
081	-	-45	$\phi_B = \phi_R - \phi_c$
082	TAN	43	$\operatorname{tg} \phi_B$
083	RCL 2	36 02	K_2
084	x	-35	$K_2 \operatorname{tg} \phi_B$
085	ABS	16 31	$\lvert K_2 \operatorname{tg} \phi_B \rvert$
086	x	54	$(K_2 \operatorname{tg} \phi_B)^2 = v_n$
087	RCL 3	36 03	v_{n-1}
088	STO C	35 13	
089	R	-31	v_n
090	STO 3	35 03	
091	RCL 6	36 06	$\cos\left(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n\right)$
092	RCL 5	36 05	$\sum_{n=1}^{n} \Delta L_n$

REGISTERS

0	1	2	3	4	5	6	7	8	9
0.5 H	K_1	K_2	$v_{n-1} \mid v_n$	$\sum_{n=1}^{n-1} \alpha_n \Delta L_n \mid \sum_{n=1}^{n} \alpha_n \Delta L_n$	$\sum_{n=1}^{n-1} \Delta L_n \mid \sum_{n=1}^{n} \Delta L_n$	$\cos\left(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n\right)$			$c_R(0)$

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
← Reserved for resistance body data →						$\Sigma \ln(D-Da)$	$\Sigma(\ln(D-Da))^2$	$\Sigma v \ln(D-Da)$	Σv
K	L	M	N						

A	B	C	D	E	I
ϕ_R		$v_{n-2} \mid v_{n-1}$	D		$n-1$

STEP	KEY ENTRY	KEY CODE	COMMENTS
093	x	-35	$\cos(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n) \sum_{n=1}^{n} \Delta Ln$
094	RCL 0	36 00	0.5 H
095	2	02	
096	x	-35	H
097	+	-55	$Da_n + 0.5\ H = H + \cos(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n) \sum_{n=1}^{n} \Delta L_n$
098	RCL D	36 14	D
099	x ⩽ y ?	16-35	If $D \leqslant Da_n + 0.5\ H$ (resistance body on drain bottom) go to label 4 for setting
100	GTO 4	22 04	flag 0 as a signal. If not, skip step 100
101	x ⇄ y	-41	$Da_n + 0.5\ H$
102	RCL 0	36 00	0.5 H
103	-	-45	Da_n
104	* LBL 3	21 03	Return label for the case $D \leqslant Da_n + 0.5\ H$
105	RCL 7	36 07	Da_{n-1}
106	-	-45	$\Delta Da_n = Da_n - Da_{n-1}$ and $\Delta Da_n = D - Da_{n-1}$ if $D \leqslant Da_n + 0.5\ H$
107	ST+7	35-55 07	Da_n
108	F 1?	16 23 01	If flag 1 is set (after the first set of data have been entered; n-1 ≠ 0)
109	GTO 2	22 02	go to label 2. If not (n-1 = 0) continue at step 110
110	2	02	
111	x	-35	$2\ Da_n = H$
112	* LBL 2	21 02	Return label for n-1 ≠ 0
			First set of data (n-1 = 0) / n-1 ≠ 0
113	2	02	
114	+	-24	0.5 H / $0.5\ \Delta Da_n$
115	RCL B	36 12	0 / $0.5\ \Delta Da_{n-1}$
116	x ⇄ y	-41	0.5 H / $0.5\ \Delta Da_n$
117	STO B	35 12	
118	+	-55	0.5 H / $0.5\ (\Delta Da_n + \Delta Da_{n-1})$
119	RCL C	36 13	0 / v_{n-1}
120	x	-35	0 / $0.5\ v_{n-1}\ (\Delta Da_n + \Delta Da_{n-1})$
121	ST+8	35-55 08	$\Sigma v \Delta Da$
122	F 0?	16 23 00	If flag 0 is set ($D \leqslant Da_n + 0.5\ H$; resistance body on drain bottom) go to label 5 in sub
123	GTO 5	22 05	programme label B for printing the results. If not, continue at step 124
124	RCL 7	36 07	Da_n
125	PRT X	-14	
126	RCL 3	36 03	v_n
127	SF 1	16 21 01	Set flag 1 as a signal that the first set of data has been entered
128	P ⇄ S	16-51	Change registers 0 - 9 with S0-S9
129	ST + 9	35-55 09	$\Sigma v = \Sigma v + v_n$
130	x ⇄ y	-41	Da_n
131	RCL D	36 14	D
132	x ⇄ y	-41	Da_n
133	-	-45	$D - Da_n$
134	LN	32	$\ln(D - Da_n)$
135	STO 4	35 04	
136	ST + 6	35-55 06	$\Sigma \ln(D-Da) = \Sigma \ln(D-Da) + \ln(D-Da_n)$
137	x^2	53	$\{\ln(D-Da_n)\}^2$
138	St + 7	35-55 07	$\Sigma\{\ln(D-Da)\}^2 = \Sigma\{\ln(D-Da)\}^2 + \{\ln(D-Da_n)\}^2$
139	R↓	-31	v_n
140	RCL 4	36 04	$\ln(D-Da_n)$

REGISTERS

0	1	2	3	4	5	6	7	8	9
0.5 H	K_1	K_2	v_n	$\sum_{n=1}^{n} \alpha_n \Delta Ln$	$\sum_{n=1}^{n} \Delta Ln$	$\cos(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta Ln)$	Da_{n-1} | Da_n	$\Sigma v \Delta Da$	$c_R(0)$
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
← Reserved for resistance body data →				$\ln(D-Da)$		$\Sigma \ln(D-Da)$	$\Sigma\{\ln(D-Da)\}^2$	$\Sigma v \ln(D-Da$	Σv
K	L	M	N						

A	B	C	D	E	I
ϕ_R	$0.5\ \Delta Da_{n-1}$ | $0.5\ \Delta Da_n$	v_{n-1}	D		n-1

STEP	KEY ENTRY	KEY CODE	COMMENTS
141	x	-35	$v_n \ln (D-Da_n)$
142	ST + 8	35-55 08	$\Sigma v \ln(D-Da) = \Sigma v \ln(D-Da) + v_n \ln(D-Da_n)$
143	ISZ I	16 26 46	n = n+1
1444	P ⇄ S	16-51	change registers 0 - 9 with S0 - S9 (original position)
145	RCL 3	36 03	v_n
146	PRT X	-14	
147	RTN	24	End of main programme
148	* LBL 4	21 04	Sub routine for setting signal (flag 0) for $D \leq Da_n + 0.5$ H (resistance body on drain bottom)
149	SF 0	16 21 00	set flag 0
150	GTO 3	22 03	Return execution at label 3
151	* LBL B	21 12	Sub programme, calculates average velovity. Part of the programme (label 5) may be called directly from the main programme as a sub routine for printing the results in case $D \leq Da_n + 0.5$ H
152	RCL 7	36 07	Da_n
153	RCL D	36 14	D
154	SPC	16-11	
155	PRT X	-14	
156	÷	-24	Da_n/D
157	.	-62	
158	8	08	0.8
159	x ⇄ y	16-35	If $Da_n/D \geq 0.8$ sufficient measurements have been taken to use equation (4-23)
160	GTO 6	22 06	for calculating the average velocity in label 6. If not, continue at step 161
161	P ⇄ S	16-51	change registers 0 - 9 and S0 - S9
162	RCL 8	36 08	$\Sigma v \ln(D-Da)$
163	RCL 6	36 06	$\Sigma \ln(D-Da)$
164	RCL 9	36 09	Σv
165	x	-35	$\Sigma v \, \Sigma \ln(D-Da)$
166	RCL I	36 46	n
167	÷	-24	$n^{-1} \Sigma v \, \Sigma \ln(D-Da)$
168	-	-45	$T = \Sigma v \ln(D-Da) - n^{-1} \Sigma v \, \Sigma \ln(D-Da)$
169	RCL 7	36 07	$\Sigma\{\ln(D-Da)\}^2$
170	RCL 6	36 06	$\Sigma \ln(D-Ds)$
171	x^2	53	$\{\Sigma \ln(D-Da)\}^2$
172	RCL I	36 46	n
173	÷	-24	$n^{-1} \{\Sigma \ln(D-Da)\}^2$
174	-	-45	$N = \Sigma\{\ln(D-Da)\}^2 - n^{-1}\{\Sigma \ln(D-Da)\}^2$
175	÷	-24	b = T/N
176	STO 4	35 04	
177	RCL 9	36 09	Σv
178	x ⇄ y	-41	b
179	RCL 6	36 06	$\Sigma \ln(D-Da)$
180	x	-35	$b\Sigma \ln(D-Da)$
181	-	-45	$\Sigma v - b\Sigma \ln(D-Da)$
182	RCL I	36 46	n
183	÷	-24	$a = n^{-1}\{\Sigma v - b \, \Sigma \ln(D-Da)\}$
184	STO 5	35 05	
185	RCL 4	36 04	b
186	÷	-24	a/b
187	CHS	-22	-a/b
188	e^x	33	$e^{-a/b}$
189	RCL D	36 14	D

REGISTERS

0 0.5 H	1 K_1	2 K_2	3 v_n	4 $\sum_{n=1}^{n} \alpha_n \Delta Ln$	5 $\sum_{n=1}^{n} \Delta Ln$	6 $\cos(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta Ln)$	7 Da_n	8 $\Sigma v \, \Delta Da$	9 $c_{R(0)}$
S0 ← K	S1 Reserved for L	S2 resistance body data → M	S3 N	S4 ln(D-Da) | b	S5 a	S6 $\Sigma \ln(D-Da)$	S7 $\Sigma\{\ln(D-Da)\}^2$	S8 $\Sigma v \ln(D-Da)$	S9 Σv
A ϕ_R	B $0.5 \Delta Da_n$	C v_{n-1}	D D	E $n-1 \mid n$	I				

STEP	KEY ENTRY	KEY CODE	COMMENTS
190	+	-24	$D^{-1}\ e^{-a/b}$
191	RCL D	36 14	D
192	LN	32	ln D
193	+	-55	$\ln D + D^{-1}\ e^{-a/b}$
194	1	01	
195	-	-45	$\ln D-1 + D^{-1}\ e^{-a/b}$
196	RCL 4	36 04	b
197	x	-35	$b(\ln D-1 + D^{-1}\ e^{-a/b})$
198	RCL 5	36 05	a
199	+	-55	$\bar{v}_p = a + b\ (\ln D-1 + D^{-1}\ e^{-a/b})$
200	P ⇄ S	16-51	change registers 0 - 9 and S0 - S9 (original position)
201	GTO 7	22 07	continue programme at label 7 (printing of result)
202	* LBL 6	21 06	sub routine average velocity if $Da_n/D > 0.8$ (sufficient measurements)
203	RCL D	36 14	D
204	RCL 7	36 07	Da_n
205	-	-45	$D-Da_n = \Delta Da_{n+1}$
206	2	02	
207	÷	-24	$0.5\ \Delta Da_{n+1}$
208	RCL B	36 12	$0.5\ \Delta Da_n$
209	+	-55	$0.5\ (\Delta Da_n + \Delta Da_{n+1})$
210	RCL C	36 13	v_n
211	x	-35	$0.5\ v_n\ (\Delta Da_n + \Delta Da_{n+1})$
212	ST + 8	35-55 08	$\Sigma v\Delta Da = \Sigma v\Delta Da + 0.5\ v_n\ (\Delta Da_n + \Delta Da_{n+1})$
213	* LBL 5	21 05	Adress label that may be called by the main programme (label A) if $D \leq Da_n + 0.5$ H (resistance body on drain bottom)
214	RCL 8	36 08	$\Sigma v\Delta Da$
215	RCL D	36 14	D
216	÷	-24	$\bar{v}_p = D^{-1}\ \Sigma v\Delta Da$
217	* LBL 7	21 07	Adress label for the case if Da/D < 0.8; this programme part prints the results and clears the flags 0 and 1, set during programme excuition
218	DSP 3	-63 03	
219	PRT X	-14	
220	SPC	16-11	
221	DSP 2	-63 02	
222	CF 0	16 22 00	clear flag 0
223	CF 1	16 22 01	clear flag 1
224	RTN	24	End of the programme

REGISTERS

0	1	2	3	4	5	6	7	8	9
0.5 H	K_1	K_2	v_n	$\sum_{n=1}^{n} \alpha_n \Delta L_n$	$\sum_{n=1}^{n} \Delta L_n$	$\cos(\phi_R - 0.5 \sum_{n=1}^{n} \alpha_n \Delta L_n)$	Da_n	$\Sigma v\ \Delta Da$	$c_{R(0)}$
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
← Reserved for resistance body data →				b	a	$\Sigma \ln(D-Da)$	$\Sigma(\ln(D-Da))^2$	$\Sigma v\ \ln(D-Da)$	Σv
K	L	M	N						

A	B	C	D	E	I
ϕ_R	$0.5\ \Delta Da_n$	v_{n-1}	D		n

8.3. Programme 'WATER QUALITY PROCESSING'

User Intructions

STEP	INSTRUCTIONS	INPUT DATA / UNITS	KEYS	OUTPUT DATA / UNITS
1	Read the card with programme 'Water quality processing'			
2	Read the card with pre-recorded data			
3	Read the cation concentrations:	Ca	ENTER ↑	
		Mg	ENTER ↑	
		Na	ENTER ↑	
		K	A	
4	Read the anion concentrations and calculate results:	CO_3	ENTER ↑	
		HCO_3	ENTER ↑	
		SO_4	ENTER ↑	
		Cl	B	Σcat-Σan
				SAR
				adj.SAR
				RSC
				EC_e
				TDS
5	For next calculation repeat step 3 and 4			

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	* LBL A	21 11	Sub programme, stores concentrations of cations (in meq. l^{-} and ppm)
002	STO 5	35 05	$[K^+]$
003	STO 7	35 07	$\Sigma cat = [K^+]$
004	R↓	-31	$[Na^+]$
005	STO 1	35 01	
006	ST + 7	35-55 07	$\Sigma cat + \Sigma cat + [Na^+]$
007	R↓	-31	$[Mg^{2+}]$
008	1	01	
009	2	02	
010	.	-62	
011	1	01	
012	5	05	
013	2	02	
014	5	05	12.1525
015	x ⇄ y	-41	$[Mg^{2+}]$
016	x	-35	ppm Mg = 12.1525 $[Mg^{2+}]$
017	STO 6	35 06	Σppm = ppm Mg
018	LST X	16-63	$[Mg^{2+}]$
019	STO 0	35 00	
020	ST + 7	35-55 07	$\Sigma cat = \Sigma cat + [Mg^{2+}]$
021	R ↓	-31	ppm Mg
022	R ↓	-31	$[Ca^{2+}]$
023	2	02	
024	0	00	
025	.	-62	
026	0	00	
027	4	04	20.04
028	x ⇄ y	-41	$[Ca^{2+}]$
029	x	-35	ppm Ca = 20.04 $[Ca^{2+}]$
030	ST + 6	35-55 06	$\Sigma ppm = \Sigma ppm$ + ppm Ca
031	LST X	16-63	$[Ca^{2+}]$
032	ST + 0	35-55 00	$[Ca^{2+} + Mg^{2+}]$
033	ST + 7	35-55 07	$\Sigma cat = \Sigma cat + [Ca^{2+}]$
034	RCL 1	36 01	$[Na^+]$
035	2	02	
036	2	02	
037	,	-62	
038	9	09	
039	3	03	
040	9	09	
041	8	08	22.9398
042	x	-35	ppm Na = 22.9398 $[Na^+]$
043	ST + 6	35-55 06	$\Sigma ppm = \Sigma ppm$ + ppm Na
044	RCL 5	36 05	$[K^+]$
045	3	03	
046	9	09	
047	.	-62	
048	1	01	
049	0	00	
050	2	02	39.102

REGISTERS

0	1	2	3	4	5	6	7	8	9
$[Mg^{2+}]$ | $[Ca^{2+}+Mg^{2+}]$	$[Na^+]$				$[K^+]$	Σppm	Σcat	0.0502443	2.03143
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
-0.168965	3.37421	-0.191873	3.08763	0.942497	0.10025	0.948705	0.135698	0.943381	0.132651

A	B	C	D	E	I
0.920797	0.132445	0.820672	0.1346		

STEP	KEY ENTRY	KEY CODE	COMMENTS
051	x	-35	ppm K = 39.102 $[K^+]$
052	ST + 6	35-55 06	Σppm = Σppm + ppmK
053	RCL 7	36 07	Σcat
054	STO E	35 15	
055	RTN	24	End of sub programme
056	* LBL B	21 12	Main programme, stores concentration of anions (in meq.l^{-1} and ppm) and calculates results
057	STO 4	35 04	$[Cl^-]$
058	STO 7	35 07	Σan = $[Cl^-]$
059	R ↓	-31	$[SO_4^{2-}]$
060	STO 3	35 03	
061	ST + 7	35-55 07	Σan = Σan + $[SO_4^{2-}]$
062	R ↓	-31	$[HCO_3^-]$
063	6	06	
064	1	01	
065	.	-62	
066	0	00	
067	1	01	
068	7	07	
069	2	02	61.0172
070	x ⇄ y	-41	$[HCO_3^-]$
071	x	-35	ppm HCO_3 = 61.0172 $[HCO_3^-]$
072	ST + 6	35-55 06	Σppm = Σppm + ppm HCO_3
073	LST X	16-63	$[HCO_3^-]$
074	STO 2	35 02	
075	ST + 7	35-55 07	Σan = Σan + $[HCO_3^-]$
076	R ↓	-31	ppm$[HCO_3^-]$
077	R ↓	-31	$[CO_3^{2-}]$
078	3	03	
079	0	00	
080	.	-62	
081	0	00	
082	0	00	
083	4	04	
084	6	06	30.0046
085	x ⇄ y	-41	$[CO_3^{2-}]$
086	x	-35	ppm CO_3 = 30.0046 $[CO_3^{2-}]$
087	ST + 6	35-55 06	Σppm = Σppm + ppm CO_3
088	LST X	16-63	$[CO_3^{2-}]$
089	ST + 2	35-55 02	$[HCO_3^-]+[CO_3^{2-}]$
090	ST + 7	35-55 07	an = an + $[CO_3^{2-}]$
091	RCL 3	36 03	$[SO_4^{2-}]$
092	4	04	
093	8	08	
094	.	-62	
095	0	00	
096	2	02	
097	8	08	
098	8	08	48.0288
099	x	-35	ppm SO_4 = 48.0288 $[SO_4^{2-}]$
100	ST + 6	35-55 06	Σppm =Σ ppm + ppm $[SO_4]$

REGISTERS

0	1	2	3	4	5	6	7	8	9
$[Ca^{2+}+Mg^{2+}]$	$[Na^+]$	$[HCO_3^-]/([HCO_3^-]+[CO_3^{2-}])$	$[SO_4^{2-}]$	$[Cl^-]$	$[K^+]$	Σppm	Σ cat|Σan	0.0502443	2.03143
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
-0.168965	3.37421	-0.191873	3.08763	0.942497	0.10025	0.948705	0.135698	0.943381	0.132651

A	B	C	D	E	I
0.920797	0.132445	0.820672	0.1346	Σ cat	

STEP	KEY ENTRY	KEY CODE	COMMENTS
101	RCL 4	36 04	$[Cl^-]$
102	3	03	
103	5	05	
104	.	-62	
105	4	04	
106	5	05	
107	3	03	35.453
108	x	-35	ppm Cl = 35.453 $[Cl^-]$
109	ST + 6	35-55 06	Σppm = Σppm + ppm Cl
110	RCL E	35 15	Σcat
111	RCL 7	36 07	Σan
112	-	-45	Σcat - Σan
113	SPC	16-11	
114	DSP 9	-63 09	
115	PRT X	-14	
116	DSP 1	-63 01	
117	8	08	Register counter n = 8
118	STO I	35 46	
119	RCL 0	36 00	$[Ca + Mg]$
120	RCL 1	36 01	$[Na^+]$
121	+	-55	$[Ca + Mg + Na]$
122	GSB 4	23 04	Go to sub routine 4 to calculate $pK_2' - pK_c' = 2.03143\ [Ca + Mg + Na]^{0.0502443}$
123	RCL 0	36 00	$[Ca + Mg]$
124	GSB 4	23 04	Go to sub routine 4 to calculate $p(Ca + Mg) = 3.37421\ [Ca + Mg]^{-0.168965}$
125	+	-55	$pK_2' - pK_c' + p(Ca + Mg)$
126	RCL 2	36 02	$[CO_3 + HCO_3]$
127	GSB 4	23 04	Go to sub routine 4 to calculate $pAlk = 3.08763\ [CO_3 + HCO_3]^{-0.191873}$
128	+	-55	$pHc = pK_2' - pK_c' + p(Ca + Mg) + pAlk$
129	CHS	-22	-pHc
130	9	09	
131	.	-62	
132	4	04	9.4
133	+	-55	9.4 - pHc
134	RCL 1	36 01	$[Na]$
135	RCL 0	36 00	$[Ca + Mg]$
136	2	02	
137	÷	-24	$[Ca + Mg]/2$
138	$\sqrt{x}$	54	$([Ca + Mg]/2)^{\frac{1}{2}}$
139	÷	-24	$SAR = \frac{[Na]}{([Ca + Mg]/2)^{\frac{1}{2}}}$
140	PRT X	-14	
141	x	-35	adj SAR = SAR (9.4 - pHc)
142	PRT X	-14	
143	RCL 5	36 05	$[K]$
144	ST + 1	35-55 01	$[Na + K]$
145	RCL 2	36 02	$[CO_3 + HCO_3]$
146	RCL 0	36 00	$[Ca + Mg]$
147	-	-45	$[CO_3 + HCO_3] - [Ca + Mg]$
148	x <07	16-45	If $[CO_3 + HCO_3] - [Ca + Mg] < 0$ RSC = 0
149	0	00	If not, skip step 149 and RSC = $[CO_3 + HCO_3] - [Ca + Mg]$

REGISTERS

0	1	2	3	4	5	6	7	8	9
$[Ca^{2+}+Mg^{2+}]$	$[Na^+]$ | $[Na+K]$	$[HCO_3^-+CO_3^{2-}]$	$[SO_4^{2-}]$	$[Cl^-]$	$[K^+]$	Σppm	Σan	0.0502443	2.03143
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
-0.168965	3.37421	-0.191873	3.08763	0.942497	0.10025	0.948705	0.135698	0.943381	0.132651

A	B	C	D	E	I
0.920797	0.132445	0.820672	0.1346	Σ cat	n

STEP	KEY ENTRY	KEY CODE	COMMENTS
150	PRT X	-14	RSC
151	RCL 1	36 01	[Na + K]
152	RCL 2	36 02	[CO_3 + HCO_3]
153	x > y?	16-34	[Na HCO_3] = smallest value of [Na + K] and [CO_3 + HCO_3]
154	x ⇄ y	-41	
155	ST-1	35-45 01	[Na + K] = [Na + K] - [Na HCO_3] (residual Na + K)
156	ST-2	35-45 02	[CO_3 + HCO_3] = [CO_3 + HCO_3] - [$NaHCO_3$] (residual CO_3 + HCO_3)
157	GSB 3	23 03	Go to sub routine 3 to calculate $\Delta EC_{NaHCO_3} = \frac{[NaHCO_3]}{\Sigma cat} \setminus 0.10025\ (\Sigma cat)^{0.942497}$
158	STO 7	35 07	$\Sigma\Delta EC = \Delta EC_{NaHCO_3}$
159	RCL 1	36 01	[Na + K] (residual Na + K)
160	RCL 4	36 04	[Cl]
161	x > y?	16-34	[NaCl] = smallest value of [Na + K] and [Cl]
162	x ⇄ y	-41	
163	ST-1	35-45 01	[Na + K] = [Na + K] - [NaCl] (residual Na + K)
164	ST-4	35-45 04	[Cl] = [Cl] - [NaCl] (residual Cl)
165	GSB 3	23 03	Go to sub routine 3 to calculate $EC_{NaCl} = \frac{[NaCl]}{\Sigma cat}\ 0.135698\ (\Sigma cat)^{0.948705}$
166	ST+7	35-55 07	$\Sigma\Delta EC = \Sigma\Delta EC + \Delta EC_{NaCl}$
167	RCL 0	36 00	[Ca + Mg]
168	RCL 4	36 04	[Cl] (residual Cl)
169	x > y?	16-34	[$CaCl_2$] = smallest value of [Ca + Mg] and [Cl]
170	x ⇄ y	-41	
171	ST-0	35-45 00	[Ca + Mg] = [Ca + Mg] - [$CaCl_2$] (residual Ca + Mg)
172	ST-4	35-45 04	[Cl] = [Cl] - [$CaCl_2$] (residual Cl)
173	GSB 3	23 03	Go to sub routine 3 to calculate $\Delta EC_{CaCl_2} = \frac{[CaCl_2]}{\Sigma cat}\ 0.132651\ (\Sigma cat)^{0.943381}$
174	ST+7	35-55 07	$\Sigma\Delta EC = \Sigma\Delta EC + \Delta EC_{CaCl_2}$
175	RCL 1	36 01	[Na_2SO_4] = [Na + K] (all residual Na + K is considered Na_2SO_4)
176	GSB 3	23 03	Go to sub routine 3 to calculate $\Delta EC_{Na_2SO_4} = \frac{[Na_2SO_4]}{\Sigma cat}\ 0.132445\ (\Sigma cat)^{0.920797}$
177	ST+7	35-55 07	$\Sigma\Delta EC = \Sigma\Delta EC + \Delta EC_{Na_2SO_4}$
178	RCL 0	36 00	[$CaSO_4$] = [Ca + Mg] (all residual Ca + Mg is considered $CaSO_4$)
179	GSB 3	23 03	Go to sub routine 3 to calculate $\Delta EC_{CaSO_4} = \frac{[CaSO_4]}{\Sigma cat}\ 0.1346\ (\Sigma cat)^{0.820672}$
180	St+7	35-55 07	$\Sigma\Delta EC = \Sigma\Delta EC + \Delta EC_{CaSO_4}$
181	RCL 7	36 07	$EC_c = \Sigma\Delta EC$
182	DSP 2	-63 02	
183	PRT X	-14	
184	RCL 6	36 06	TDS = Σppm
185	5	05	
186	+	-55	TDS + 5
187	1	01	
188	0	00	
189	÷	-24	(TDS + 5)/10
190	DSP 0	-63 00	
191	INT	16 34	Int (TDS/10 + 0.5)
192	1	01	
193	0	00	

REGISTERS

0	1	2	3	4	5	6	7	8	9
[Ca + Mg]	[Na + K]	[HCO_3+CO_3]	[SO_4]	[Cl]	[K]	Σ ppm	Σan|ΣΔEC	0.0502443	2.03143
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
-0.168965	3.37421	-0.191873	3.08763	0.942497	0.10025	0.948705	0.135698	0.943381	0.132651

A	B	C	D	E	I
0.920797	0.132445	0.820672	0.1346	Σcat	n

STEP	KEY ENTRY	KEY CODE	COMMENTS
194	x	-35	TDS (rounded to nearest 10) = 10 Int (TDS/10 + 0.5)
195	PRT X	-14	
196	DSP 2	-63 02	
197	RTN	24	End of main programme
198	* LBL 3	21 03	Sub routine for the calculation of the ΔEC of the different salts
199	RCL E	36 15	Σcat
200	GSB 4	23 04	Go to sub routine 4 to calculate $a(\Sigma cat)^b$
201	$x \rightleftarrows y$	-41	[Salt]
202	RCL E	36 15	Σcat
203	+	-24	[Salt]/Σcat
204	x	-35	$\Delta EC_{salt} = \frac{[salt]}{\Sigma cat}\ a(\Sigma cat)^b$
205	RTN	24	End of sub routine
206	* LBL 4	21 04	Sub routine for the calculation of power function: $y = ax^b$
207	RCL i	36 45	b (0.0502; - 0.169; -0.192; 0.942; 0.949; 0.943; 0.921; 0.821)
208	ISZ I	16 26 46	n = n+1
209	y^x	31	$[\ ]^b$
210	RCL i	36 45	a (2.03; 3.37; 3.09; 0.100; 0.136; 0.133; 0.132; 0.135)
211	ISZ I	16 26 46	n = n+1
212	x	-35	$a\ [\ ]^b$
213	RTN	24	End of sub routine

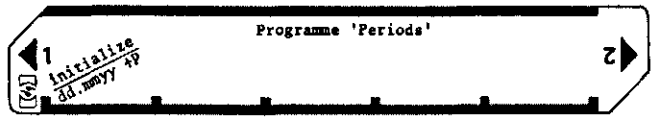
REGISTERS

0	1	2	3	4	5	6	7	8	9
						Σppm	ΣΔ EC	0.0502443	2.03143
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
-0.168965	3.37421	-0.191873	3.08763	0.943497	0.10025	0.948705	0.135698	0.943381	0.132651

A	B	C	D	E	I
0.920797	0.132445	0.820672	0.1346	Σcat	n

8.4. PROGRAMME "PERIODS"

User Intructions



STEP	INSTRUCTIONS	INPUT DATA / UNITS	KEYS	OUTPUT DATA / UNITS
1	Read the card with programme 'Periods'			
2	Initialize the main programme		f A	
3	Read first measurement date	dd.mm yy	A	
4	Read next measurement date and print result	dd.mm yy	A	P
5	Repeat step 4 for all measurement dates			

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	* LBL a	21 16 11	Initialize the main programme
002	SPC	16-11	
003	3	03	
004	6	06	
005	5	05	
006	.	-62	
007	2	02	
008	5	05	365.25
009	STO A	35 11	
010	3	03	
011	0	00	
012	.	-62	
013	6	06	
014	0	00	
015	0	00	
016	1	01	30.6001
017	STO B	35 12	
018	0	00	Set counter n to 0 (n=0)
019	STO I	35 46	
020	CF 1	16 22 01	Clear flag 1
021	RTN	24	End of sub programme
022	* LBL A	21 11	Main programme
023	F 1?	16 23 01	If flag 1 is set,
024	ISZ I	16 26 46	increase the counter n with 1 (n=1)
025	GSB 1	23 01	Go to sub routine 1 to calculate J - 1720982
026	STO i	35 45	Store J-1720982 in register n
027	F 1?	16 03 01	If flag 1 is set
028	GSB 2	23 02	go to sub routine 2 to calculate and print P
029	SF 1	16 21 01	set flag 1
030	RTN	24	End of main programme
031	* LBL 1	21 01	Sub routine to calculate Julian Day Number minus 1720982
032	ENT↑	-21	dd.mm yy
033	INT	16 34	dd = d - day number
034	STO C	35 13	
035	-	-45	0.mm yy
036	EEX	-23	
037	2	02	100
038	x	-35	mm.yy
039	ENT↑	-21	
040	INT	16 34	mm = m - month number
041	STO D	35 14	
042	-	-45	0.yy
043	1	01	
044	9	09	
045	+	-55	19.yy
046	EEX	-23	
047	2	02	100
048	x	-35	19 yy = y - year number (A.C.)
049	STO 7	35 07	
050	RCL D	36 14	m

REGISTERS

0	1	2	3	4	5	6	7	8	9
J_1-1720982	J_2-1720982						y		
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**

A	B	C	D	E	I
365.25	30.6001	d	m		n

STEP	KEY ENTRY	KEY CODE	COMMENTS
051	1	01	
052	+	-55	m+1
053	ENT+	-21	
054	1/X	52	1/(m+1)
055	.	-62	
056	7	07	
057	+	-55	1/(m+1) + 0.7
058	CHS	-22	-1/(m+1) - 0.7
059	INT	16 34	-1 If m = 1 or 2; 0 if m > 2
060	ST + 7	35-55 07	y' = y-1 if m=1 or 2; y'= y if m > 2
061	1	01	
062	2	02	
063	x	-35	-12 if m=1 or 2; 0 if m > 2
064	-	-45	m' = m+13 if m = 1 or 2; m' = m+1 if m > 2
065	RCL B	36 12	30.6001
066	x	-35	30.6001 m'
067	INT	16 34	Int (30.6001 m')
068	RCL 7	36 07	y'
069	RCL A	36 11	365.25
070	x	-35	365.25 y'
071	INT	16 34	Int (365.25 y')
072	+	-55	Int (30.6001 m') + Int (365.25 y')
073	RCL C	36 13	d
074	+	-55	J-1720982 = Int (30.6001 m') + Int (365.25 y') + d
075	RTN	24	End of sub routine
076	* LBL 2	21 02	Sub routine to calculate and print P
077	RCL 1	36 01	J_2 - 1720982
078	RCL 0	36 02	J_1 - 1720982
079	-	-45	P = J_2 - J_1
080	PRT X	-14	print P
081	RCL 1	36 01	J_2-1720982
082	STO 0	35 00	J_1-1720982 = J_2-1720982
083	DSZ I	16 25 46	Decrease the counter n with 1 (n=0)
084	RTN	24	End of sub routine

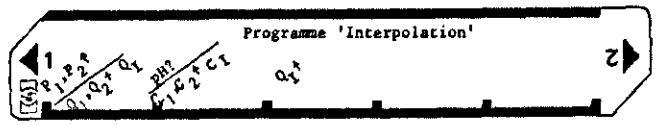
REGISTERS

0	1	2	3	4	5	6	7	8	9
J_1-1720982	J_2-1720982						y | y'		
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**

A	B	C	D	E	I
365.25	30.6001	d	m		n

8.5. PROGRAMME "INTERPOLATION"

User Intructions



STEP	INSTRUCTIONS	INPUT DATA / UNITS	KEYS	OUTPUT DATA / UNITS
1	Read the card with programme 'Interpolation'			
2	Read the periods P_1 and P_2 and store in the calculator	P_1	ENTER ↑	
		P_2	f A	
3	Read the discharges Q_1 and Q_2 and calculate Q_I	Q_1	ENTER ↑	
		Q_2	A	Q_I
4	If the measurement point is a pump station: calculate			
	Q_I by hand and store in the calculator. If not: omit step 4	Q_1	ENTER ↑	
		Q_2	+	
		2	÷	
			C	
5	If the pH is going to be calculated next: set flag 1. If not: omit this step		f B	
6	Read the concentrations C_1 and C_2 (or pH_1 and pH_2) and calculate the interpolated value	C_1	ENTER ↑	
		C_2	B	C_I
7.	Repeat step 5 (if applicable) and step 6 for all concentrations			
8	For the next data of interpolation repeat steps 2 - 7			

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	* LBL a	21 16 11	In this sub programme P_1 and P_2 are stored
002	STO 1	35 01	P_2
003	R↓	-31	P_1
004	STO 0	35 00	
005	RTN	24	End of sub programme
006	* LBL A	21 11	This is the main programme for calculating Q_I
007	STO 3	35 03	Q_2
008	R↓	-31	Q_1
009	STO 2	35 02	
010	RCL 3	36 03	Q_2
011	-	-45	$Q_1 - Q_2$
012	CHS	-22	$Q_2 - Q_1$
013	RCL 0	36 00	P_1
014	RCL 1	36 01	P_2
015	+	-55	$P_1 + P_2$
016	÷	-24	$(Q_2-Q_1)/(P_1+P_2)$
017	RCL 0	36 00	P_1 $\frac{Q_2-Q_1}{P_1-P_2}$
018	x	-35	
019	RCL 2	36 02	Q_1
020	+	-55	$Q_I = Q_1 + P_1 \frac{Q_2 - Q_1}{P_1 + P_2}$
021	STO 6	35 06	
022	SPC	16-11	
023	DSP 2	-63 02	
024	PRT X	-14	Print Q_I
025	RTN	24	End of main programme
026	* LBL b	21 16 21	In this sub programme flag 1 is set if pH_I needs to be calculated in LBL B
027	SF 1	16 21 01	Set flag 1
028	RTN	24	End of sub programme
029	* LBL B	21 12	This is the main programme for calculating C_I or pH_I
030	F 1?	16 23 01	If flag 1 is set,
031	GSB 1	23 01	go to sub routine 1 to calculate the H^+ concentration: C_2
032	STO 5	35-05	C_2
033	R↓	-31	C_1 or pH_1
034	F 1?	16 23 01	If flag 1 is set
035	GSB 1	23 01	go to subroutine 1 to calculate the H^+ concentration C_1
036	STO 4	35 04	C_1
037	RCL 3	36 03	Q_2
038	RCL 5	36 05	C_2
039	x	-35	Q_2C_2
040	RCL 2	36 02	Q_1
041	RCL 4	36 04	C_1
042	x	-35	Q_1C_1
043	-	-45	$Q_2C_2 - Q_1C_1$
044	RCL 0	36 00	P_1
045	RCL 1	36 01	P_2
046	+	-55	$P_1 + P_2$
047	÷	-24	$(Q_2C_2 - Q_1C_1)/(P_1 + P_2)$
048	RCL 0	36 00	P_1

REGISTERS

0	1	2	3	4	5	6	7	8	9
P_1	P_2	Q_1	Q_2	C_1	C_2	Q_I			
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

STEP	KEY ENTRY	KEY CODE	COMMENTS
049	x	-35	$P_1 \quad \frac{Q_2C_2 - Q_1C_1}{P_1 + P_2}$
050	RCL 2	36 02	Q_1
051	RCL 4	36 04	C_1
052	x	-35	Q_1C_1
053	+	-55	$Q_1C_1 + P_1 \frac{Q_2C_2-Q_1C_1}{P_1+P_2}$
054	RCL 6	36 06	Q_I
055	÷	-24	$C_I = \frac{Q_1C_1 + P_1 \frac{Q_2C_2 - Q_1C_1}{P_1 + P_2}}{Q_I}$
056	F 1?	16 23 01	If flag 1 is set
057	GSB 2	23 02	go to sub routine 2 to convert the interpolated H^+ concentration to pH_I
058	DSP 1	-63 01	
059	PRT X	-14	Print C_I or pH_I
060	RTN	24	End of main programme
061	* LBL 1	21 01	This sub routine converts the pH to H^+ concentration
062	CHS	-22	-pH
063	10^x	16 33	$C = 10^{-pH}$
064	RTN	24	End of sub routine
065	* LBL 2	21 02	This sub routine converts H^+ concentration to pH
066	LOG	16 32	Log $[H^+]$
067	CHS	-22	pH = - Log $[H^+]$
068	CF 1	16 22 01	Clear flag 1 for next calculations
069	RTN	24	End of sub routine
070	* LBL C	21 13	Sub programme for storing Q_I (pump stations)
071	STO 6	35 06	Q_I
072	RTN	24	End of sub programme

REGISTERS

0	1	2	3	4	5	6	7	8	9
P_1	P_2	Q_1	Q_2	C_1	C_2	Q_I			
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

8.6 PROGRAMME "MONTHLY AVERAGE"

User Intructions

STEP	INSTRUCTIONS	INPUT DATA / UNITS	KEYS	OUTPUT DATA / UNITS
1	Read the card with programme 'Monthly average'			
2	Read number of periods N, initialize programme and store N	N	f A	
3	Read period length 's P_i	P_i	A	
4	Repeat step 3 for all periods P_i			
5	Read discharge Q_i	Q_i	B	
6	Repeat step 5 (N+1 times) until the programme calculates the average discharge			$\bar{Q}$
7	If the measurement point is a pump station: calculate the average discharge (equation 6 - 1a) and store $\bar{Q}$:	Q_I 10 Q_{II} 10 Q_{III} P_{III} * $(20 + P_{III})$	ENTER↑ x ENTER↑ x + ENTER↑ x + ÷ f B	$\bar{Q}$
8	For the calculation of the average pH: set flag 1		f C	
9	Read concentration C_i (or pH_i)	C_i	C	
10	Repeat step 9 (N+1 times) until the programme calculates the average concentration (or pH)			$\bar{C}$
11	Repeat steps 8-10 until all average concentrations have been calculated			
12	For the next month repeat steps 2 - 11			

*P_{III} = 8 in february in non-leap years
9 in february in a leap year (1980 is a leap year)
10 in april, june, september and november
11 in january, march, may, july, august, october and december

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	* LBL a	21 16 11	In this sub programme the registers for the sums are cleared and N is stored
002	CLR G	16-53	$\Sigma P_i = \Sigma\frac{1}{2}P_i(Q_i+Q_{i+1}) = \Sigma\frac{1}{2}P_i\ (Q_{i+1}C_{i+1} + Q_iC_i)$ = counter n = 0
003	1	01	
004	-	-45	N-1
005	STO E	35 15	
006	RTN	24	End of sub programme
007	* LBL A	21 11	In this sub programme the periods P_i are stored inregisters 0-5
008	STO i	35 45	Store P_1 in register 0; P_2 in register 1; etc.
009	RCL A	36 11	ΣP_i
010	+	-55	$\Sigma P_i = \Sigma P_i + P_i$
011	STO A	35 11	
012	RCL E	36 15	N-1
013	RCL I	36 46	n
014	x = y?	16-33	If n = N-1 (≡ last input value of P_i),
015	GTO 1	22 01	go to label 1 to prepare counter for reading discharges
016	ISZ I	16 26 46	n = n+1
017	RTN	24	End of sub programme if more data P_i have to be read
018	* LBL 1	21 01	Part of sub programme LBL A executed after the last P_i data entry
019	6	06	
020	STO I	35 46	n = 6
021	RTN	24	End of sub programme after last P_i data entry
022	* LBL b	21 16 12	Sub programme to store Q (pump stations)
023	STO C	35 13	$\bar{Q}$
024	RTN	24	End of sub programme
025	* LBL B	21 12	Main programme for the calculation of $\bar{Q}$
026	STO i	35 45	Store Q_1 in register 6; Q_2 in register 7; etc.
027	6	06	
028	RCL I	36 45	n
029	x = y?	16-33	If n=6 (≡ first Q_i data entry):
030	ISZ I	16 26 46	prepare counter for next data entry: n = n+1 = 7
031	x = y?	16-33	If first Q_i data entry:
032	RTN	24	stop execution to read next Q_i value
033	RCL i	36 45	Q_{i+1}
034	DSZ I	16 25 46	n = n+1
035	RCL i	36 45	Q_i
036	+	-55	$Q_{i+1} + Q_i$
037	2	02	
038	÷	-24	$\frac{1}{2}\ (Q_{i+1} + Q_i)$
039	RCL I	36 46	n
040	6	06	
041	-	-45	n = n-6
042	R↓	-31	$\frac{1}{2}(Q_{i+1} + Q_i)$
043	RCL i	36 45	P_i
044	x	-35	$\frac{1}{2}\ P_i(Q_{i+1} + Q_i)$
045	RCL B	36 12	$\Sigma\frac{1}{2}\ P_i(Q_{i+1} + Q_i)$
046	+	-55	$\Sigma\frac{1}{2}\ p_i(Q_{i+1} +Q_i) = \Sigma\ \frac{1}{2}\ P_i\ (Q_{i+1} + Q_i) + \frac{1}{2}\ P_i\ (Q_{i+1} + Q_i)$
047	STO B	35 12	
048	RCL E	36 15	N-1
049	RCL I	36 46	n
050	x = y?	16-33	If n = N-1 (≡ last input value of Q_i),

REGISTERS

0	1	2	3	4	5	6	7	8	9
← Reserved for P_i					→	← reserved for Q_i			→
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
← Reserved for Q_i		→	← Reserved for C_i		→				→

A	B	C	D	E	I
ΣP_i	$\Sigma\frac{1}{2}\ P_i(Q_{i+1} + Q_i)$	$\bar{Q}$		N-1	n

STEP	KEY ENTRY	KEY CODE	COMMENTS
051	GTO 2	22 02	go to label 2 to calculate $\bar{Q}$
052	8	08	
053	+	-55	n = n+8
054	STO I	35 46	
055	RTN	24	End of main programme if more data Q_i have to be read
056	* LBL 2	21 02	Part of main programme LBL B to calculate $\bar{Q}$, executed after the last Q_i data entry
057	RCL B	36 12	$\Sigma\downarrow P_i(Q_{i+1} + Q_i)$
058	RCL A	36 11	ΣP_i
059	÷	-24	$\bar{Q} = \{\Sigma\downarrow P_i(Q_{i+1}+Q_i)\} / (\Sigma P_i)$
060	STO C	35 13	
061	SPC	16 11	
062	DSP 2	-63 02	
063	PRT X	-14	Print $\bar{Q}$
064	SPC	16 11	
065	1	01	
066	3	03	
067	STO I	36 46	n = 13
068	RTN	24	End of main programme
069	* LBL c	21 16 13	Sub programme to set flag 1 for the calculation of average pH
070	SF 1	16 21 01	Set flag 1
071	RTN	24	End of sub programme
072	* LBL C	21 13	Main programme for calculation $\bar{C}$ or $\overline{pH}$
073	F 1?	16 23 01	If flag 1 is set (≡ input is pH)
074	GSB 4	23 04	go to sub routine 4 to convert pH to concentration
075	STO i	35 45	*store C_1 in register 13; C_2 in regrester 14; etc*
076	1	01	
077	3	03	13
078	RCL I	36 45	n
079	x = 0?	16-33	If first C_i data entry: (n=13)
080	ISZ I	16 26 46	prepare counter for next data entry: n = n+1 = 14
081	x = y?	16-33	If first C_i data entry:
082	RTN	24	stop execution to read next C_i (or pH) value
083	RCL i	36 45	C_{i+1}
084	RCL I	36 46	n
085	7	07	
086	-	-45	n= n-7
087	STO I	35 46	
088	R↓	-31	C_{i+1}
089	RCL i	36 45	Q_{i+1}
090	x	-35	$Q_{i+1}\ C_{i+1}$
091	DSZ I	16 25 46	n = n-1
092	RCL i	36 45	Q_i
093	RCL I	36 46	n
094	7	07	
095	+	-55	n= n+7
096	STO I	35 46	
097	R↓	-31	Q_i
098	RCL i	36 45	C_i
099	x	-35	Q_iC_i
100	+	-55	$Q_{i+1}C_{i+1} + Q_iC_i$

REGISTERS

0	1	2	3	4	5	6	7	8	9
	Reserved for P_i					Reserved for Q_i			
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
Reserved for Q_i				Reserved for C_i					

A	B	C	D	E	I
ΣP_i	$\Sigma\downarrow P_i(Q_{i+1} + Q_i)$	$\bar{Q}$		N-1	n

STEP	KEY ENTRY	KEY CODE	COMMENTS
101	2	02	
102	+	-24	$\Sigma\,(Q_{i+1}C_{i+1} + Q_iC_i)$
103	RCL I	36 46	n
104	1	01	
105	3	03	
106	-	-45	n = n-13
107	STO I	35 46	
108	$R^\downarrow$	-31	$\Sigma\,(Q_{i+1}C_{i+1}+Q_iC_i$
109	RCL i	36 45	P_i
110	x	-35	$\Sigma\, P_i(Q_{i+1}\,C_{i+1} + Q_iC_i)$
111	RCL D	36 14	$\Sigma\Sigma\, P_i(Q_{i+1}C_{i+1}+Q_iC_i)$
112	+	-55	$\Sigma\Sigma\, P_i(Q_{i+1}C_{i+1}+Q_iC_i)+\Sigma\,\Sigma\, P_i(Q_{i+1}C_{i+1}+Q_iC_i) + \Sigma\, P_i(Q_{i+1}C_{i+1}+Q_iC_i)$
113	STO D	35 14	
114	RCL E	36 15	N-1
115	RCL I	36 46	n
116	x = y?	16-33	If n = N-1 (last input value of C_i):
117	GTO 3	22 03	go to label 3 to calculate $\bar{C}$
118	1	01	
119	5	05	
120	+	-55	n = n+15
121	STO I	35 46	
122	RTN	24	End of main programme if more data C_i (or pH_i) have to be read
123	* LBL 3	21 03	Part of main programme LBL C to calculate $\bar{C}$ after the last C_i data entry
124	RCL D	36 14	$\Sigma\,\Sigma\, P_i\,(Q_{i+1}C_{i+1} + Q_iC_i)$
125	RCL A	36 11	$\Sigma\, P_i$
126	+	-24	$\bar{L} = \{\Sigma\,\Sigma\, P_i\,(Q_{i+1}C_{i+1} + Q_iC_i)\}\ /(\Sigma\, P_i)$
127	RCL C	36 13	$\bar{Q}$
128	+	-24	$\bar{C} = \bar{L}/\bar{C}$
129	F 1?	16 23 01	If flag 1 is set ($\bar{C}$ output is $\overline{pH}$)
130	GSB 5	23 05	go to sub routine 5 to convert concentration to pH
131	DSP 1	-63 01	
132	PRT X	-14	Print $\bar{C}$
133	1	01	
134	3	03	
135	STO I	35 46	n = 13 (preparation counter for next set of concentration data)
136	0	00	
137	STO D	35 14	$\Sigma\,\Sigma\, P_i\,(Q_{i+1}C_{i+1} + Q_iC_i) = 0$
138	RTN	24	End of main programme
139	* LBL 4	21 04	This sub routine converts pH to concentration
140	CHS	-22	$-pH_i$
141	10^x	16 33	$C_i = 10^{-pH}$
142	RTN	24	End of subroutine
143	* LBL 5	21 05	This sub routine converts concentration to pH
144	LOG	16 32	Log $[H^+]$
145	CHS	-22	pH = Log $[H^+]$
146	CF 1	16 22 01	Clear flag 1
147	RTN	24	End of sub routine

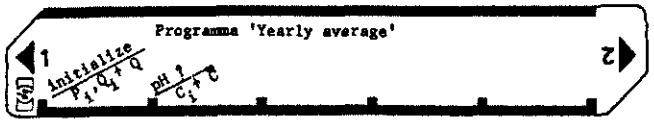
REGISTERS

0	1	2	3	4	5	6	7	8	9
←	Reserved for P_i	→			→	← Reserved for Q_i	→		
S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
← Reserved for Q_i	→	→	←		Reserved for C_i		→		

A	B	C	D	E	I
ΣP_i	$\Sigma\,\Sigma\, P_i\,(Q_{i+1} + Q_i$	$\bar{Q}$	$\Sigma\,\Sigma\, P_i\,(Q_{i+1}C_{i+1}+Q_iC_i$	N-1	n

8.7. PROGRAMME "YEARLY AVERAGE"

User Intructions



STEP	INSTRUCTIONS	INPUT DATA / UNITS	KEYS	OUTPUT DATA / UNITS
1	Read the card with programme 'Yearly average'			
2	Initialize the programme		f A	
3	Read period length and discharge for month i	P_i	ENTER	
		Q_i	A	
4	Repeat step 3 until all 12 P_i and Q_i data have been read			
	the calculator will print the average discharge			$\bar{Q}$
5	For the calculation of average pH: set flag 1		f B	
6	Read concentration (or pH) for month i	C_i	B	
7	Repeat step 6 until all 12 concentrations have been read;			
	the calculator will print the average concentration			$\bar{C}$
8	Repeat step 5 (if applicable) to 7 until all ions have been calculated			
9	Repeat step 2-8 for the next measurement point			

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	* LBL a	21 16 11	In this sub programme the registers are initialized
002	CRL G	16-53	$\Sigma P_i = \Sigma\ P_iQ_i = \Sigma P_iQ_iC_i = 0$
003	3	03	
004	STO I	35 46	Counter n = 3
005	RTN	24	End of sub programme
006	* LBL A	21 11	Main programme for the calculation of $\bar{Q}$
007	$x \overset{+}{\div} y$	-41	P_i
008	STO + 0	35-55 00	$\Sigma P_i = \Sigma P_i + P_i$
009	x	-35	P_iQ_i
010	STO i	35 45	Store P_iQ_i in reggister 3; P_2Q_2 in register 4; etc.
011	ISZ I	16 26 46	n = n+1
012	STO+1	35-55 01	$\Sigma P_iQ_i = \Sigma P_iQ_i + P_iQ_i$
013	RCL I	36 46	n
014	1	01	
015	5	05	
016	x > y ?	16-34	If n ≤ 15 (date of december not yet entered),
017	RTN	24	stop execution to read next set of input data
018	RCL 1	36 01	$\sum_{i=1}^{12} P_iQ_i$
019	RCL 0	36 00	$\sum_{i=1}^{12} P_i$
020	÷	-24	$\bar{Q} = \sum_{i=1}^{12} P_iQ_i / \sum_{i=1}^{12} P_i$
021	SPC	16-11	
022	PRT X	-14	Print $\bar{Q}$
023	SPC	16-11	
024	3	03	
025	STO I	35 46	restore n = 2
026	RTN	24	End of main programme
027	*LBL b	21 16 12	In this sub programme flag 1 is set to indicate pH input data
028	SF 1	16 21 01	Set flag 1
029	RTN	24	End of sub routine
030	* LBL B	21 12	Main programme for the calculation of $\bar{C}$ (or $\overline{pH}$)
031	F 1?	16 23 01	If flag 1 is set,
032	GSB 1	23 01	convert pH to concentration in sub routine 1
033	RCL i	36 45	P_iQ_i
034	x	-35	$C_iQ_iP_i$
035	STO+2	35-55 01	$\Sigma C_iQ_iP_i = \Sigma\ C_iQ_iP_i + C_iQ_iP_i$
036	ISZ I	16 26 46	n = n+1
037	RCL I	36 46	n
038	1	01	
039	5	05	
040	x > y?	16-34	If n ≤15 (data of december not yet entered),
041	RTN	24	stop execution to read next C_i (or pH)
042	RCL 2	36 02	$\sum_{i=1}^{12} P_iC_iQ_i$
043	RCL 1	36 01	$\sum_{i=1}^{12} P_iQ_i$
044	÷	-24	$\bar{C} = \sum_{i=1}^{12} P_iC_iQ_i / \sum_{i=1}^{12} P_iQ_i$
045	F 1?	16 23 01	If flag 1 is set
046	GSB 2	23 02	convert concentration to pH in sub routine 2

REGISTERS

0	1	2	3	4	5	6	7	8	9
ΣP_i	ΣP_iQ_i	$\Sigma P_iC_iQ_i$	←		reserved for	P_iQ_i data			→

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
← reserved	for P_iQ_i data			→					

A	B	C	D	E	I
					n

STEP	KEY ENTRY	KEY CODE	COMMENTS
047	DSP 1	-63 01	
048	PRT X	-14	Print $\bar{C}$ (or $\overline{pH}$)
049	DSP 2	-63 02	
050	CP 1	16 22 01	Clear flag 1
051	0	00	
052	STO 2	35 02	$\Sigma P_i Q_i C_i = 0$
053	3	03	
054	STO I	35 46	n = 3
055	RTN	24	End of main programme
056	* LBL 1	21 01	Sub routine to convert pH to concentration
057	CHS	-22	-pH
058	10^x	16 33	$C = 10^{-pH}$
059	RTN	24	End of sub routine
060	* LBL 2	21 02	Sub routine to convert concentration to pH
061	LOG	16 32	log C
062	CHS	-22	pH = - log C
063	RTN	24	End of sub routine

REGISTERS

0	1	2	3	4	5	6	7	8	9
ΣP_i	$\Sigma P_i Q_i$	$\Sigma P_i Q_i C_i$	← reserved for $P_i Q_i$ data →						

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
←	reserved for $P_i Q_i$ data →								

A	B	C	D	E	I
					n

شكـــــــر

هذا التقرير قام باعداده الكاتب نتيجه لتواجـــــــدة في معهد بحوث الصرف في الفتره من ١٩٧٧ – ١٩٨٢ وتلـــى ذلك زيارتين في شهر فبراير – مارس في ابريل – مايـــو ١٩٨٢ ، في نهايه عام ١٩٨١ كلف باعداد هذا التقريـــر عن القياسات الروتينيه التي يقوم بها معهد بحوث الصـــرف طبقـا لتوصيات المجلس الاستشاري المصري الهولنـدي .

يود الكاتب ان يعبـر عن امتنانه للدكتور / محمد حســـن عامـر مدير معهد بحوث الصرف والذي بناء على ارشاداتـــه تمت وتمت دراسات استخدامات مياه الصرف حتى وصلـــت الى المرحله الحاليه . وشكـر الى الدكتوره / ساميـــة الجنـدي والتي والتي بجانب عملها كرئيسه لشعبه المعامـــل وشعبه التقييم الاقتصادي كانت مستعده دائما لتنظيـــم العمل في شعبه استخدام مياه الصرف وتحمل جزء من انشطـــة الشعبـه .

يود المؤلف ايضا شكـر الدكتور / ضياء الدين القوصـــى والذي بعد التحاقه بالمعهد عام ١٩٨٠ الم سريعا بدراســات استخدام مياه الصرف واصبح رئيسا للشعبه . وحاليا تقـــوم الدكتوره ساميه الجندي والدكتور ضياء القوصي بالاشـــراف على توجيه مهندسي الشعبه .

ويود المؤلف عن شكـره لمهندس الشعبه الذي اشتـــــرك معهـم في القياسات الحقليه الروتينيـة .

محمـد سعد عبـــــاس
سمير عبد الحميـــــد
محمد عبد الخالـــــق
جمال عبد الناصـــــر
عادل عبد الرشيـــــد
محمد عيســـــــى
محمـد عـــــــزت
سامي فرغلـــــــى
محمـد نجيـــــب
عبد المنعم مدبولـــى
احمد مرســـــــى
عويس حامـــــــد

والذين نتيجه لنشاطهم الدائم تحت الظروف الصعبه تـــم تجميع البيانات الحقليه بصوره مرضيه .

يشير المؤلف الى المساعدات التي قدمها رئيس الخبـــراء الهولنديين بمعهد بحوث الصرف الخبير مستر ريتسبو (حتى يناير ١٩٨٠) والمستر فان ليفن (حتى ابريل ١٩٨٠) والمستر فان دبرزيل (اعتبارا من مايو ١٩٨٠) .

يعتبـر هذا العمل احد انشطه المجلس الاستشاري المصـــرى الهولنـدي وتم بمساعده معهد بحوث اداره الاراضي والميـــاة بفاجننجن الذي يشترك الان مع معهد بحوث الصرف في مشـروع اعاده استخدام مياه الصرف الذي بدء اعتبارا من ١٩٨٣.

قامت المهندسه ليلى السيس باعداد ماده الفصل الثالـــث عن التحاليل المعمليه . وقام المستر مايز باعداد مـــادة الجزء الثاني والجزء الرابع بالفصل الرابع عن المعايرات

مقدمـــــــه

لقد اصبح اعاده استخدام مياه الصرف فى الرى والذى لايعتبر حديثا فى مصر من أهم مصادر استراتيجيه وزاره الـــرى لاستصلاح الاراضى . أذ يعتبر من أهم المصادر التى يمكن الاستفاده بها خلال المرحله القادمه لسد العجز فى الميزانية المائيه وتحقيق متطلبات التوسع الافقى .

ولاستخدام هذه المياه بنجاح لابد من دراسه وتقييم تأثير الاملاح الموجوده فى مياه المصارف على التربة والنبات .

ولتقوم وزاره الرى بالتخطيط للمشاريع التى تعتمد على مياه الصرف من المهم ضبط المعلومات عن نوعيه وكميه المياه والمواقع الملائمه للاستخدام .

منذ عام ١٩٥٤ يقوم معهد بحوث الاراضى والمياه التابع لوزاره الزراعه بدراسه نوعيه وكميه مياه بعض المصارف فى جمهوريه مصر العربيه كذلك قام المعهد باجراء بعض التجارب المعمليه لدراسه تأثير الاملاح الموجودة بمياه المصارف على التربه والنبات .

اعتبارا من ١٩٧٦ تضمنت اعمال المجلس الاستشارى المصرى الهولندى دراسات اعاده استخدام مياه الصرف . فمنذ عام ١٩٧٧ بدء معهد بحوث الصرف جمع عينات دوريه شهريه من حوالى ٤٧ مصرف ومحطه طلمبات صرف منتشره فى دلتا نهر النيل لتحليلها بمعامل المعهد وتحديد نوعيتها .

وفى عام ١٩٧٩ قام المعهد بمسح شبكه المصارف المكشوفة الدلتا والفيوم وتم وضع شبكه لنقط القياس (شكل رقم ١ ـ ١) كما يوضح الشكل

وذلك طبقا للتقرير الذى اعده فولكر (a ١٩٧٩ ـ b ١٩٧٩ ـ ١٩٨٠) واعتبارا من عام ١٩٨٠ بدء جمع البيانات عن التصرفات ونوعيه المياه باستخدام طرق قياس مبسطه ومازال برنامج القياس هذا قائم لان .

واستكمالا لبرنامج جمع البيانات هذا بدء المعهد خلال ١٩٨١ برنامج متكامل لمعايره وحدات جميع محطات الصرف وذلك طبقا لتوصيات معهد الهيدروليكا بدلفت (سخونمان ١٩٨١ ـ b ١٩٨١ ـ ١٩٨٢) ووضع هذا البرنامج بغرض ايجاد العلاقه المسماة بمنحنيات التصرف .

منذ عام ١٩٨١ بدء المعهد فى اتخاذ قرار لعمل نموذج رياضى لوصف العلاقه بين الرى والصرف والانتاج المحصولى لدلتا النيل وذلك بالتعاون مع معهد بحوث اداره الاراضى والمياه بفاجننجن بهولندا (ريتما ١٩٨١ ـ ريتما ـ روست ١٩٨٢)

وتطوير هذا النموذج الرياضى يعتمد على كثافة نقط القياس وتتابع ودقه القياسات للبرنامج الذى تحت التنفيذ الان .

والموضوع الذى يعالج فى هذا التقرير مرتبط ببرامج القياسات والمعايرات الذى بدء ها المعهد عام ١٩٨٠ ، ١٩٨١ وكذلك مرتبط ببرنامج تركيب الاجهزه الذى بدءه المعهد حاليا للحصول على البيانات والقياسات اليوميه . بعض الطرق الموضحه فى هذا التقرير ممكن استعمالها فى هذه القياسات وبعضها الاخر ممكن ان تستخدم فى تطوير طرق القياس الى أدق واحدث .

والغرض من هذا التقرير هو وضع تقرير مفصل للبيانات الحقلية وتحليل البيانات وتوضيح طرق جمع البيانات وتحليلها وحسابها للمهندسين العاملين بشعبه اعاده استخدام مياة الصرف ويشمل التقرير ايضا امثله مفصله لطرق الحساب وقد يستعمل هذا كمرجع لمهندسى الشعبه وكبدايه لمعرفة اعمال الشعبه للمهندسين الجدد الذين يلتحقون بالشعبه .

يتم فى الفصل الثانى من التقرير وصف طرق تجميع البيانات الحقليه تفصيليا طبقا لبرنامج القياسات الذى يقوم به المعهد وفى الفصل الثالث يتم وصف التحاليل المعمليه التى تتم على عينات المياه ، الفصل الرابع يتضمن تحليل البيانات والفصل الخامس اختبار البيانات والفصل السادس طرق عرض البيانات .

توجد البيانات الحقليه المبدئيه فى الملحق رقم (١) وتحليل وتصحيح البيانات موجوده فى الملاحق المتتاليه .

مشروع اعادة استخدام مياة الصرف

تقرير رقم ١

المرجع فى تجميع البيانات، عرضها وتحليلها، لبرنامج القياسات الدوريه ـ قصير المدى

ك. و. ى. روست

١٩٨٣

معهد بحوث ادارة الاراضى والمياة

واخننجن، هولندا

مشروع اعاده أستخدام مياه الصرف نشاط مشترك بين :-

معهد بحوث الصرف - الجيزه - جمهوريه مصر العربية

ومعهد بحوث اداره الاراضى والمياة - فاجننجن - هولندا

وتعتبر الجهه الممولة للمشروع وزاره الرى بجهوريه مصر العربية ووزاره العلاقات الخارجيه بهولندا فى أطار البرنامج المشترك للتعاون الفنى بين مصر وهولندا .

ويعمل المجلس الاستشارى المصرى الهولندى كهيئه مشرفة .

نتائج الدراسات التى تمت خلال هذا المشروع ستعرض اما فى تقارير مبدئية او تقارير نهائيه . حيث ان محتويات التقارير المبدئيه ممكن تختلف بشدة من تقديم مبسط للبيانات او مناقشات لنتائج وخلاصات بحثيه .

الاراء والتوصيات الموجوده فى التقارير السابقه تعتبر اراء المؤلف فقط وليس لها علاقه بالمعاهد اوالوزارات المعنية .

بسم الله الرحمن الرحيـم

"وجعلنـا من المـاء كل شـى حـى"

صدق الله العظيـــم